FULL-SIZE PLANS—*A Balanced Wing Model and a*

15¢ ★

MODEL AIRPLANE NEWS

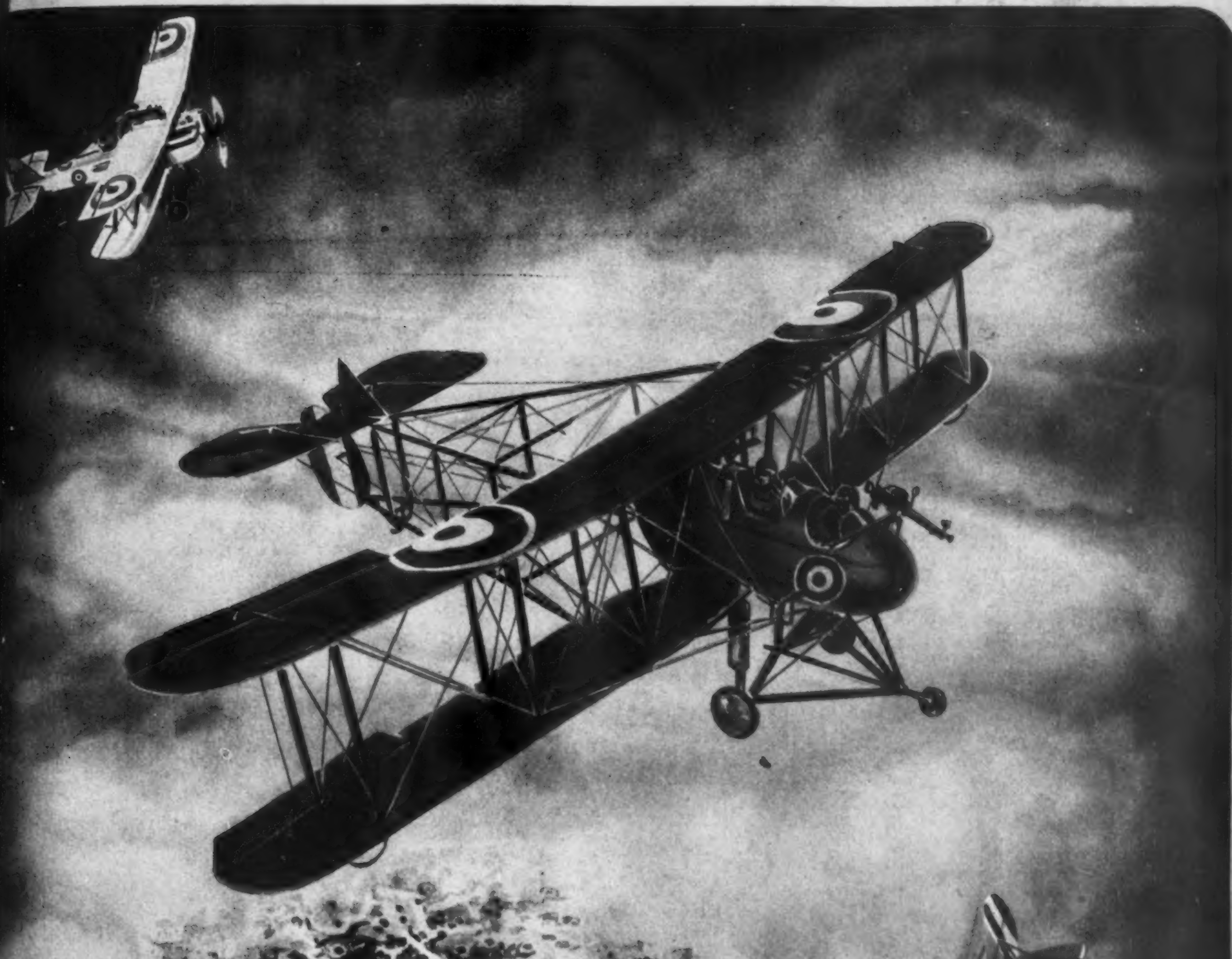
Trans-Atlantic Planes In Review

Wartime Plane—3-View Layout

More on Engines, Radio, Designing

FEBRUARY, 1932

"A COURSE IN AVIATION FOR FIFTEEN CENTS A MONTH!"



An S.E5a, and F.E2b, and an R.E8 (*British*) Artillery Spotting—Wartime

Model Airplane News

and JUNIOR MECHANICS

Published by Harold Hersey
Edited by Chas. Hampson Grant

CONTENTS

FEBRUARY, 1932

Vol. VI No.

In Our Next Issue

There has been a crying need in the past for some practical system that will enable a boy to design his model plane correctly without many trials and unsuccessful attempts. We are therefore pleased to announce that in this issue and those to follow you will find a series of articles by Mr. Charles Hampson Grant that covers the subject of model design in every detail. These articles will give you practical "rules of thumb" for designing your model and extensive tables as well as a simple and detailed description of the theory involved. There has been so much published regarding the construction of planes that we feel these articles on the principles of design will be very serviceable to you.

There are plans for a novel model glider by Mr. Stockton Ferris. This glider may be built either as a "tail first" glider or as one of usual design, namely tail in the rear. In the April issue further description will be given as to how this glider may be motorized. This should prove a very interesting craft to build. Upon tests this machine has made a glide in still air of 15 to 1.

The month of March ushers in another interesting issue of MODEL AIRPLANE NEWS. You cannot afford, as a model builder, to be without this publication every month. Make your reservation now. Our regular "Courses" continue.

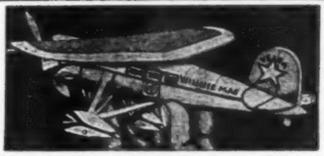
ANNOUNCEMENT BY THE PUBLISHER
I take pleasure in introducing Mr. Grant as the new editor of your magazine Model Airplane News. Mr. Grant has given many years to enthusiastic work for aviation. He has built models and flown them ever since boyhood. Way back in 1909 he started his pioneer efforts. Today he stands alone as an authority. Feel free at any time to ask him questions. Write him about your problems. He knows model building inside out. He has attended hundreds of competitions. He knows many of the leading aviators and will have much to tell you in future issues of flying and fliers.

Published Monthly by MODEL AIRPLANE NEWS PUBLISHING CORP., Myrick Bldg., Springfield, Mass.
Editorial and General Offices, 1926 Broadway, New York City.
S. W. Hennessey, President. Irene T. Kennedy, Treasurer. Wesley F. Pape, Secretary.
J. W. LeBaron, Advertising Manager, 1926 Broadway, New York, N. Y.
Entered as second-class matter June 5, 1929, at the Post Office at Springfield Mass., under the Act of March 3, 1879.

Price 15c a copy in U. S. and in Canada. Subscription price $1.50 a year in the United States and its possessions; also Canada, Cuba, Mexico and Panama.
All other countries $2.00 per year.
Chicago Advertising Office: 333 North Michigan Ave., C. H. Shattuck, Manager.
London Agents: Atlas Publishing & Distributing Co., Ltd., 18 Bride Lane, London, E. C.

REAL VALUE IN NATIONAL KITS

MIDGET LOCKHEED SIRIUS
Construction Set, Postpaid......... $1.10
Ready to Fly, Postpaid 4.40



MIDGET LOCKHEED VEGA
Construction Set, Postpaid......... $1.10
Ready to Fly, Postpaid 4.40

MIDGET TEXACO
Construction Set, Postpaid......... $1.10
Ready to Fly, Postpaid 4.40

NATIONAL Model Engineers present you the best in Midget Kits for only $1.10 each (postpaid).

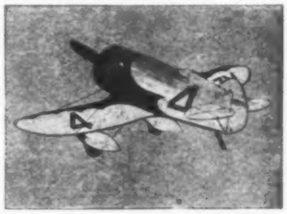
It is important to note that each National kit is complete in every detail, and packed in sturdy individual boxes.

The quality of material, accurately sized balsa, many ready made parts, all wire parts shaped, the most beautiful assortment of true colored tissue covering with insignias assure you of building a perfectly balanced and beautiful model.

Important: Strips in all NATIONAL sets are cut to size. NATIONAL does not expect the model builder to cut as perfectly as our accurately gauged Machines do.

All NATIONAL KITS are as represented. Your money back, if not satisfied. NATIONAL has served its thousands of customers satisfactorily—we want to please you, too.

MIDGET LAIRD—400
Construction Set, Postpaid.... $1.10
Ready to Fly, Postpaid......... 4.40



MIDGET GEE-BEE SPORTSTER
Construction Set, Postpaid..... $1.10
Ready to Fly, Postpaid........ 5.00

MIDGET POLISH P-6
Construction Set, Postpaid.... $1.10
Ready to Fly, Postpaid........ 4.40

MIDGET SPAD
Construction Set, Postpaid..... $1.10
Ready to Fly, Postpaid........ 4.40

MIDGET FOKKER D-7
Construction Set, Postpaid..... $1.10
Ready to Fly, Postpaid........ 4.40

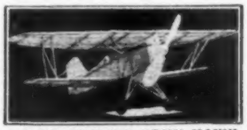
MIDGET BOEING P-12
Construction Set, Postpaid............ $1.10
Ready to Fly, Postpaid............... 4.40

MIDGET S. E. 5
Construction Set, Postpaid..... $1.10
Ready to Fly, Postpaid........ 4.40

OTHER MIDGET MODELS

- Midget Nieuport
- Midget Sopwith-Camel
- Midget Albatross
- Midget Pfalz
- Midget Fokker Triplane
- Midget Curtiss Hawk
- Midget Curtiss Falcon
- Midget Heath
- Midget Curtiss Robin
- Midget Sikorsky
- Midget Bellanca

AGENTS WANTED
We want one dealer or agent in every town to handle National Model Airplane Sets and Supplies. Because of their proven quality, a National model dealer with sets and parts to supply immediate wants can make big money. Write for full details.
Name ....
Address ....



2 FT. CURTISS ARMY HAWK
Complete Construction Set $3.00

2 FT. BOEING P-12
Complete Construction Set $3.75

Other Two-Foot Models For You To Build

Each Construction Set is Complete.

Gee-Bee	$3.00
Laird-400	3.00
Lockheed Sirius	3.00
Stinson Detroiter	3.50
Fokker D-7	3.00
S. E. 5	3.00
Nieuport Scout	3.00
Spad	3.00
Texaco 13	3.50
Albatross	3.00
Fokker Triplane	3.00
Vought Corsair	3.75
Heath Parasol	3.00

Any Model Ready to Fly - only $12.00

A few words about NATIONAL'S line of 24" flying scale models and complete line of high quality supplies.

There are fifteen models in the 24" line: All are good flying models. Their construction is simple. Try one! You will be as pleased with them as are many others.

National carries only the best in supplies. Our line is complete. We carry all kind of insignias to make your models a perfect miniature of the big ship itself.

Some National supplies may be slightly higher in price than offered by others—but the quality you receive will give you far more satisfaction than the saving of pennies. Constant repeat orders prove this.

Send Today 5 cents for our latest Catalog. All Orders are Shipped Same Day as Received.

NATIONAL MODEL AIRCRAFT & SUPPLY CO.
299 North Ave. New Rochelle, N. Y. Dept. A-21

The Aerodynamic Design of the Model Plane

By Charles Hampson Grant

This is the first of a series of articles by a practical designer of model planes with a lifetime experience put at your service. In these articles information will be given which has taken twenty years to collect. Here you will find answers to many of the puzzling problems that have mystified the model builders.

SO MANY of my model-building friends have requested information regarding the design of model planes that I have decided to present the important facts of model design in printed form.

Much has been written about the "building" of model planes, but very little concerning the proper procedure of "design." Naturally a machine must be properly designed aerodynamically if it is to fly well when constructed. It rather appears, that heretofore we have tried to "build our house," before laying in the foundation upon which it is to rest. How is it possible to build a model plane that will perform properly, before we understand how to proportion it correctly? It simply cannot be done, and I believe most of the unsuccessful models that have been built, have failed to perform in a proper manner because of the builder's lack of knowledge concerning the correct position and proportioning of surfaces and weights.

A six minute flight has been made by this All Balsa Model which embodies the Principles of Design given in this series of articles.

It is true that the model-builder has recourse to many excellent books on aerodynamics, but such books "leave the reader in mid air," so to speak, without giving him any hint as to how to apply the theory practically, in the model that he builds. It has been necessary for him to work out this for himself. It is a difficult task and one worthy of those advanced in aeronautic theory.

However, in the pages to follow, practical and simple methods, or "rules of thumb," will be presented which will enable the average model enthusiast to apply "theory" successfully. If questions arise in your mind which you would like to have me answer, write them out and send them to me in care of this magazine. I shall try to answer them to your satisfaction.

Necessary Factors for Flight

The flight of a model plane is a wonderful thing when one pauses to think about it. A machine heavier than air, rising from the ground with apparently nothing supporting it, just floating in space, meanwhile balancing and controlling itself automatically as if a real pilot were at the controls. It is a thing of mystery. This, in fact, is why model building is so interesting. There is always some new mystery to solve, always some new record to break. So now, here we are out to "bag" some ideas on the subject. In order that we may get a clear picture of the problem of design we must start at the very beginning, so let us suppose that we know nothing about an airplane and ask ourselves this question. "What basic factors or qualities must a flying machine possess in order that it will fly successfully, then, when we determine what these qualities are, how are we going to build them into our model planes?" This really states the whole problem.

Factors Nos. 1 and 2. "Lift," Propulsion

The first necessary factor or quality is obvious. It is "lift." Our plane must be able to rise from the ground into the air. However, after the plane is off the ground it must travel forward, somewhere. In fact, in order that our plane lift, it must be able to move forward at a sufficient speed. In other words, a flying machine should have *a means of propulsion.* This is our second necessary factor.

Now that we have our machine off the ground and travelling somewhere, we are not sure that it will remain on level keel. It must not turn over, nose dive, stall or do other startling antics that many of our machines execute on the slightest provocation.

Stability. Factor No. 3

It must be stable and remain in its true course of flight, or if upset, or turned over on its side from this position, it must automatically return to the proper flight attitude as quickly as possible if a crash is not to result. It must

overcome wind currents and other disturbing influences. Many of our models can rise from the ground, but not all of them have this last quality, that of *stability*, our third factor of flight. The secret lies in the proper arrangement of the various "surfaces," (wings, tail, body, etc., and weights), not necessarily in supplying a particular mechanical factor or part to the structure of the machine.

Factor No. 4—The Landing Gear

So far, we have our model off the ground, travelling forward through the air, and flying in stable flight, but now comes the end of the flight. It must land safely without damage. It must be either strong enough to drop down on the ground or else have suitable landing gear, similar to the landing gear of large planes. We may call this factor number four. That is, a *means of landing*.

Factor No. 5—The Frame

We now have considered nearly all the factors necessary for flight, but they are of no use unless they are all held together in their proper position, relative to one another. So we find that a structure or framework of some kind is necessary to accomplish this. We will call this factor number five. It is the *framework or body*.

Factor No. 6—The Control

In the case of a large, full-sized machine, a means of control is supplied, in order to direct the machine while in flight, which is operated by the pilot from his seat in the cockpit of the plane. However, there can be no pilot in a model to do this in a direct manner. It must be designed to automatically control itself and hold to a predetermined course in response to an arrangement of the surfaces and weights that are established before the start of the flight.

Do not confuse control with stability. "Control" refers to the ability to govern the course or path of the model's flight. That is, its turning to the right or left, its altitude, climb, glide or landing on or near a predetermined spot. It requires a thorough understanding of the theory of flight and design to be able to "control" or govern the flight of a model in this manner, so we will take up the study of this sixth factor last of all. If we can build a machine that embodies all of these six factors to a reasonable degree, we can operate it successfully from a mechanical standpoint.

Now our task becomes more difficult. Many of the experimenters and scientists working on the problem of flight knew *what* factors were necessary. But, what mechanical means were they to use in order to have their machines operate properly? How could they build a machine that would be able to rise from the ground, move forward, hold its true course and land on the ground again safely? Also to reasonably control the course of flight while in the air? This was the problem that took centuries to solve, and is now the one that we must solve. It is a much easier one for us, however, as we have the information and facts to use that have been established by thousands of experiments made since the "day" of the early pioneers.

Our task is to devise some mechanical apparatus that will embody all of these six qualities, so let us go over the problem of each factor *separately* and find out some of the principles of their operation.

Lift—(How It Is Obtained)

Factor No. 1 is Lift. In the case of airplanes, "lift" is secured in sufficient amount to cause the machine to rise from the ground by drawing a wing or "surface" forward through the air with the front edge raised slightly so the air may strike the under side. This angle that the wing presents to the flow of the air is called the angle of attack. Diagram No. 1 shows a flat surface in the position described with the air passing around it, as it does under these conditions.

The surface A-B is moving from right to left. The air flows around it as shown by the heavy lines.

Through the action of the air as it flows over and under the wing surface, enough upward pull is generated to lift the airplane from the earth.

We can demonstrate this fact with a piece of cardboard about three inches wide and twelve inches long. Hold it extended out in the air by one end without moving it forward, and the air has no effect upon it. However, if we should move it quickly through the air with the long front edge tilted or raised slightly, we find it has a tendency to lift. The air strikes the under side and bounces or is forced downward, causing a push upward against the cardboard. Also a slight vacuum is created on the topside of the cardboard. (V), Fig. No. 1. It is the combination of these two effects that gives lift to the wing. It has been found

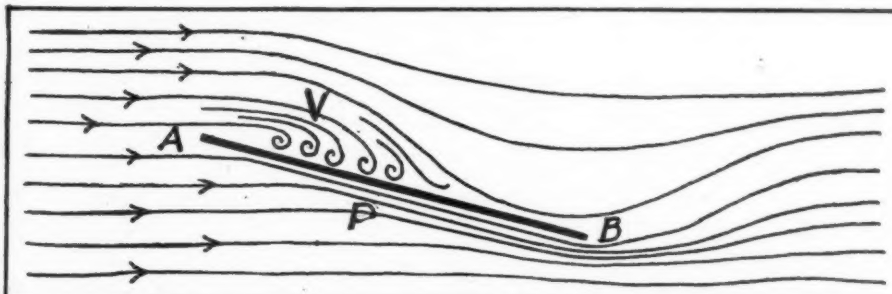


Fig. #1.

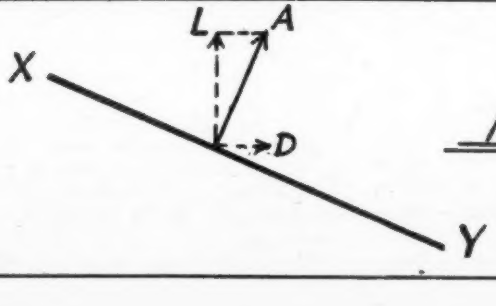


Fig. #2.

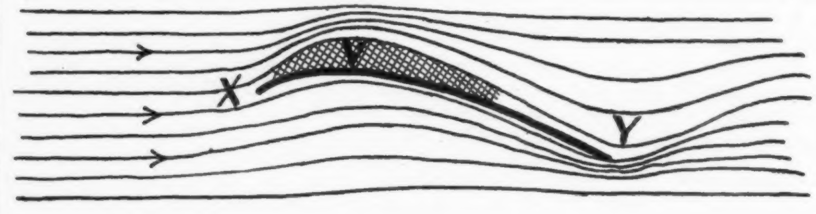


Fig. #3.

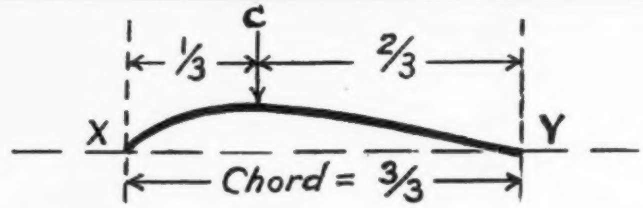


Fig. #4.

Fig. #5.

that the vacuum over the wing causes about three-quarters of the lift while the added pressure under the wing causes the remaining one-quarter of the lift.

In Diagram No. 2, an arrow (A) indicates the direction and amount of pressure that the air creates on the surface.

This force (A) is a combination of a lift (L) and a drag or resistance (L-A) or (D), because the force (A) pulls upward, yet slightly backward. So we have not only lift (L) but a resistance to the forward motion of the wing. This resistance which is called the "drag" of the wing must be overcome by applying power to push the wing forward.

Curved Wings

The air does not flow smoothly but instead, fairly "boils" over this flat wing, (V), Fig. No. 1 and causes a great deal of resistance or drag, but if the wing is curved, as shown in Fig. No. 3, we find that it has a greater tendency to lift with less pushing effort. In other words, it gives more "lift" with less "drag." This is due to the fact that the air flows smoothly over this surface without boiling or eddying as shown by the heavy lines representing air flow in Fig. No. 3.

We know, therefore, that it is best to use curved, or what we call *cambered* wings, on our models.

Wing Efficiency

This relation between the lift and the drag, we call the "lift-drag ratio." It is the lift divided by the drag, is, L/D. This ratio is important in telling us how efficient our wing is. If the lift is large and the drag is small, then we say our wing is efficient. The L/D ratio of a flat wing in flight is about five, that is, the lift is five times as great as the drag. The L/D ratio of a properly curved wing as shown in Fig. No. 3 is from 10 to 15. That is, the lift on such a wing is ten to fifteen times as great as the drag or its resistance to forward motion. So we see that the flying qualities of our models depend a great deal upon what shape we give to the wing section, or aerofoil, as we call it.

Proper Aerofoil Shape

In Fig. No. 3, you will notice that the curve of the wing is not a perfect arc of a circle but that the highest point comes nearer the front edge (X) than the rear edge (Y). This is what we call a parabolic wing. It is the best form to use.

The highest point (C) of the curve, Fig. No. 4 should be located back of the front edge (X) about one-third of the distance from (X) to (Y). The distance, (X-Y) we call the chord of the wing. In other words, (X-C) should be equal to one-third of the chord (X-Y).

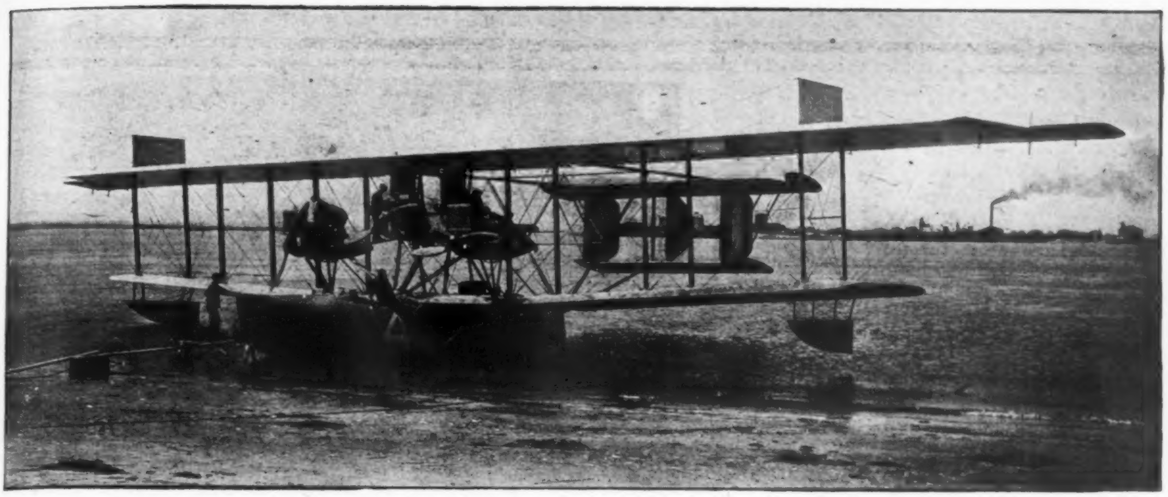
Double Surface Wings

Up to this point we have been talking about wings of one single curve, the upper and lower side of the wing being the same shape. This type of wing section is called a single surface wing and is the simplest type to build. Most of the early gliders and power planes had wings of this type.

However, through constant experiment to develop a more efficient style of section, the so-called double surface wing was evolved. Fig. No. 5 shows a single surface wing, (A), and a double surface one, (B).

This later developed wing section was found to be very efficient. It not only gives greater lift, but the drag is greatly decreased, so much so, in fact, that some of the sections that have been developed have given L/D (lift-drag ratio) of 23. That is, the lift is 23 times as much as the drag. The increase in efficiency is partly due to the elimination of the slight vacuum which formed back of the leading edge of a single surface wing as shown at (M), Fig. No. 5. Also, the wing spars may be enclosed within the wing in the case of a double-surface wing, while they were exposed to the air in the old type, thus causing unnecessary drag.

The curve of the upper (*Continued on page* 44)



The Trans-Atlantic Navy Curtiss (N. C. 4)

Trans-Atlantic Planes

Some interesting comments on early attempts to span the Atlantic by air; how these attempts formed the basis for such sensational achievements as that of the DO-X in the present day

By H. J. Heindell

IN PRACTICALLY every line of achievement and with each new discovery there have been those who have blazed the trail and have just fallen short of the goal. Still their sacrifices in money, and in some cases their lives have not been without their effect. In human make-up there is the desire to accomplish something new, whether it may be a mountain peak to climb or new countries to explore.

Crossing the Atlantic by air had its inception many years ago. Aviation personalities in 1912 ventured the opinion that ocean crossing by aircraft in time to come would be the accepted mode of travel to Europe. Statements in that year by the late Glenn H. Curtiss told us that sometime we would see the Flying Boat developed along the lines of a palatial yacht with sleeping quarters for owner, guests and crew. Mr. Curtiss predicted that these large flying yachts would be sea-worthy, comfortable and fast, but we cannot help wondering if even his inventive genius forsaw the high rate of speed and mammoth proportions to which Flying Boats would grow.

By 1912 it seemed that the land aircraft had accomplished all that could be reasonably expected of this type. Bleriot had flown across the English Channel, Robinson had flown the length of the Mississippi River, from its source to its mouth, the American continent had been spanned and Chavez in Europe had flown over the Alps.

At this time pontoons or floats were not new, for aircraft operation over water, but it was Mr. Curtiss, carrying out his prediction, who brought out the first flying boat having a true boat hull as its passenger and crew carrying quarters. This small ship could travel but one mile a minute, and was of limited cruising range; but we must remember that its further development bore fruit in the shape of the multi-engine ships of today.

With the successful Trans-Atlantic flights of 1927-28 aeronautical interest began to return to the design of large type flying boats capable of crossing large bodies of water with sizeable payloads, and with large degree of safety. The result of this renewed interest in 1927 is seen in such modern craft as the DO-X and the giant Sikorsky S40.

Present day accomplishment is only the result of again taking up and finishing large flying boat projects started as early as 1914, and incorporating new developments here and there.

First Flying Boats

The forerunner of the now familiar flying boat was, as we know, developed by Curtiss, and had a very limited range of activity, but with this first effort once made, development went constantly forward until the further possibilities of the flying boat were soon no longer questioned. Rodman Wanamaker was among the first to be impressed by the possibilities of an ocean crossing, and authorized the construction of the first enclosed cabin flying boat to be built, the "AMERICA." This was the first multi-engine flying boat carrying two pusher type engines mounted between the wings. Successful tests were made, and all speci-

fications met. Preparation was being made for the crossing of the Atlantic when a mishap occurred to the propeller on one of the motors. By the time a new propeller had been procured, the World War had started. Regretfully, Wanamaker decided to postpone the attempt to span the Atlantic, thereby depriving the "AMERICA" of honors that might have been hers. Yet many ships of this type later found themselves doing patrol work over the English Channel.

Built for War Purposes

During the war (1915 and 1916) a multi-engine flying boat, as large as the DO-X, was built, about which little has ever been made known. This large aircraft was designated the model "T." It was designed by the late Glenn H. Curtiss, and built by the Curtiss Aeroplane Company.

Much interest has been displayed in the gigantic size of the DO-X since its arrival in this country, but until the advent of the DO-X this country's own 1916 model "T" was the largest heavier-than-air aircraft ever built. This airplane was designed for war purposes and was constructed under the necessary war restrictions and secrecy. Because of the hazards of ocean travel by boat it was intended to fly the model "T" ship to the scene of conflict. But this monster was built for the British Admiralty, and a last minute decision to install English engines in this craft made necessary the abandonment of the ocean hop.

The model "T" hull, or passenger carrying unit, was built of wood, the accepted type of construction of that day. Very carefully laid out light members, securely braced and engineered, made up the hull structure. The outside and bottom parts were covered with several layers of thin mahogany, between which was inserted a waterproofing material. Such was the ship's size that it was necessary to transport the hull and wings from the factory at Buffalo to the point of departure overseas by the water route of the Erie Canal and Hudson River. Railway cars could not accommodate the huge boxes containing various parts of the ship.

Details of Construction

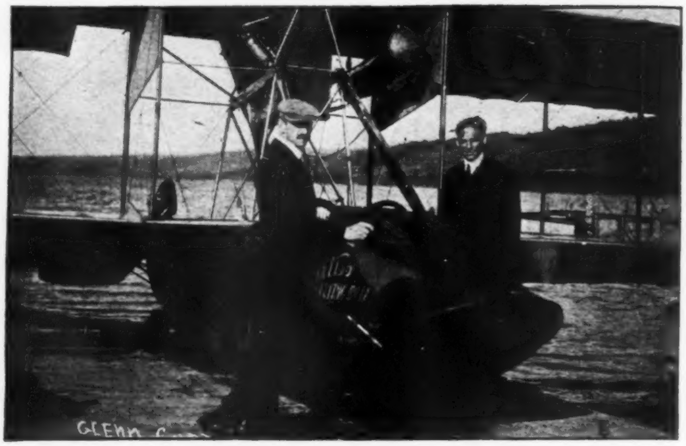
The wing construction of this mighty plane was of the three wing, or tri-plane type, one wing being mounted over the other like three shelves. The power plant consisted of four motors in the center wing, tractor fashion.

The model "T's" empennage or tail grouping consisted of triple rudders, with only one fin coming up from the boat hull to meet the sternpost. One long horizontal stabilizer, and two elevators with the full width of the stabilizer completed the tail group. This arrangement was unique, as the top horizontal surface or elevator was hinged to the top of the rudder posts, and not to a fixed surface, as is the generally accepted design arrangement. The width of the tail group was much larger in span than the span of the main wings of the average commercial plane. The span of the wings, of tri-plane arrangement, was 137 feet.

This mammoth boat was capable of carrying in its cabin nearly one hundred persons. The control compartment for two pilots occupied the forward end of the boat and was entirely enclosed, yet gave unobstructed vision to pilot and navigator.

In reality, the model "T" in size and outline was the forerunner of the DO-X type of today, except that in the DO-X we have the one monoplane wing doing the work of the "T's" three.

During the construction of this craft changes in design and in plans came often, and it was one of these last minute changes in plans, that is, the decision to install Rolls-Royce motors in England, that robbed this early bird of being the first to make the ocean crossing by air.



Glenn Curtiss and Henry Ford look over early Curtiss Flying Boat at Hammondsport, 1913

NC-4 Crossing Remarkable Undertaking

The NC-4 in May, 1919, was the first aircraft to successfully cross the Atlantic, and in this undertaking Mr. G. H. Curtiss again played an important part. "NC" implies a combination of effort by the Navy and Curtiss.

The year 1917 saw aeronautical designing moving along at a rapid rate, with the war calling for bigger and better aircraft. Naturally the question was again raised regarding the transportation of implements of war by boat, to avoid the danger of loss through the enemy's submarine warfare, then being waged very intensely. The Navy Department reached a decision to construct four large flying boats and actually send them to France under their own power. Drawings were made, and hull lines laid down in the fall of 1917. Construction started in winter and spring of 1918 at the new Curtiss plant at Garden City, L. I., N. Y. This undertaking required the services of many trained men. The co-operation of many engineering minds, both in and out of the industry, greatly assisted in the design and construction of the various units, such as gasoline tanks, radiators, propellers, armament, and the production of all special parts.

How Model "T" and the NC-4 Differed

The "NC" type of construction departed radically from the "DO-X" and the "T," in that it used outrigger booms or spars for the tail erection. This construction is the same as is now used on all Sikorsky ships. The NC-4 type had an overall width of 126 feet, with a length of 55 feet. Height from keel to top of wing was twenty-two feet, while the boat hull was 12 feet wide. The large hull contained six gasoline tanks with capacities of three hundred gallons each. Supplementing these six was an overhead wing gravity tank of 100 gallons. The original layout for military work called for a Davis non-recoil gun, mounted on the gunner's cockpit ring at the extreme nose of the ship. In addition, a machine gunner's nest was mounted atop the center wing and reached by a steel ladder.

Armistice Intervenes and Prevents Crossing as Man of War

The first of the "NC" group was completed in November, 1918, just after the signing of the armistice. This first

plane was designated the NC-I, and mounted three Liberty motors. In view of the fact that the NC-I transported fifty-one Navy "Gobs" from the Air Station at Rockaway, L. I., to Atlantic City and return, the reader will get some idea of the immense carrying capacity of the NC type of craft. On the NC-I a pusher motor was later mounted aft, and in line with the center motor. This change was also followed on the balance of the ships.

Preparation went forward in the spring of 1919 for the ocean crossing of the NC ships under the leadership of Commander A. C. Read, U. S. Naval Air Station. After various trial, load and radio, tests, the three ships made their first hop to St. Johns, where they awaited good weather for the second leg of the journey to the Azores. Ships of the surface fleet of the U. S. Navy were stationed at intervals of fifty miles along the route to relay radio calls or go to the assistance of any of the flyers in case of necessity. The NC-4 made the crossing of this second lap without mishap, landing at Horta in the Azores. But the remaining two planes were forced down en route. The NC-3 came down close to the surface for observation and even made contact with the water, but due to the heavy sea running at the time she was unable to attain flying speed and could not get off again. After drifting helplessly in the sea she was fortunately picked up by one of the surface fleet.

Alcock and Brown after their flight. Capt. Alcock, a model enthusiast, and Lt. Brown holding the first Trans-Atlantic air mail bag

The NC-4, however, after an interval at Horta, continued on to Lisbon, Portugal and then to England, thus connecting the United States and England by air for the first time.

Alcock and Brown Make Successful Attempt

Those intrepid airmen Sir John Alcock and Sir Arthur Whitten Brown, flying a Vimy-Vickers Bi-plane took off from St. Johns, Newfoundland, on their memorable attempt to span the Atlantic, on June 14th, 1919. Their Vimy-Vickers was of the type built in England for bombing work over the front and with its ability for transporting heavy loads, the Alcock-Brown ship was well suited to their purpose. These two men were the first to make a non-stop flight across the Atlantic. Their remarkable feat followed, only by a matter of days, the successful spanning of the Atlantic by the NC-4.

At the time of the flight there was much anxious waiting for word from these two flyers. Their plane was equipped with radio and their silence caused some anxious moments among those who followed their undertaking with interest. Ships in the Trans-Atlantic shipping lane were asked by the British Air Ministry to be on the lookout for their plane or for signals from their radio, but no word came until Alcock and Brown landed in Ireland. It was then learned that a broken drag wire had carried away the propeller blade of their radio generator.

Tanks for fuel on this Vimy-Vickers Bomber displaced the bombs and bombing apparatus to such an extent that in skeleton, while being assembled, the machine looked like a collection of cylinders or tanks. The nose of the ship formed one tank, the center section of the upper wing another, and, running back from the cockpit, were six other tanks holding about 100 gallons each. The life raft tank was carried in much the same manner as Hawker carried the emergency boat on his Sopwith.

The flyers had scant room in their cockpit. Alcock acted as pilot separated only by inches from the wheel with which he controlled the machine. He was completely surrounded by instruments, valves for the operation of the ship, and control valves for trimming the gasoline tanks, for it must be remembered that in order to have proper balance around the center of gravity fuel had to be drawn proportionally from all tanks at the same time. Brown, however, got a better deal, and had more room. This was necessary for his observations, only three of which were made, due to bad weather.

The successful conclusion of the flight was due to the great determination of these men. They never wavered, though following closely the ill-fated attempt of Hawker and Greive. The elapsed flying time for negotiating this water hop was sixteen hours and twelve minutes.

DO-X Embodies Old and New Principles of Design

The Dornier DO-X flying boat which but recently completed a delayed Trans-Atlantic flight is in reality a "bringing together or summing up," as it might be called, of old principles, added to the pioneer Claude Dornier's researches in metal hull and wing construction.

In 1916 we had the model "T" with a boat hull of the DO-X type, except that sponsons were employed in place of lateral fins or stub wings, as are used on the DO-X. The adoption of steel and duralumin for wood is an advance in keeping with current developments, and in the matter of supporting surfaces we find the monoplane wing replacing the multi-wings of years gone by. No change is noticeable in tail grouping or water rudder control. Usual flying boat practice is to construct water tight bulkheads across the hull at different intervals, with watertight doors inter-connecting. The displacement of any two compartments being such that they would sustain flotation of the ship.

The interior of the DO-X is divided longitudinally by decks of which there are three, the uppermost one containing the pilots' quarters and other compartments necessary to the proper navigation of the ship, and is located just forward of the leading edge of the wing. The hull of the DO-X is deep enough from keel to top of wing to allow the ship to ride out a fairly heavy sea and the whole ship is not only seaworthy (*Continued on page* 41)

The Airplane Engine

The Diesel Engine

By Lt. (jg) H. B. Miller, U. S. N.

(*CHAPTER 9*)

IT IS a startling fact that not many years ago, gasoline was thrown away in open fields and poured into rivers in an effort to get rid of this dangerous by-product of crude petroleum. At that time, the most highly desired distillate of crude oil was kerosene, which could be used for illuminating purposes.

Gasoline, being explosive could not safely be used in wick-lamps. Thus, when the automobile came into use, at the beginning of the Twentieth Century, there was a surplus of excellent fuel in the country. Since then, progress in the design of the internal combustion engine has closely followed the development of fuels suitable for use in those powerplants.

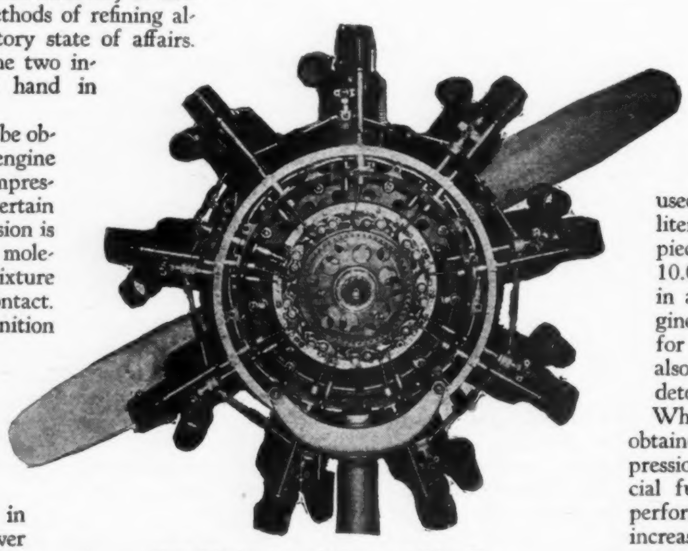
The advent of the automobiles formed a profitable market for this heretofore useless oil. Since there were but few cars throughout the country they were naturally supplied with the highest grade of gasoline.

This condition lasted until the close of the World War when the huge numbers of automobiles began to create a shortage in the gasoline supply. The result of this increased demand for fuel caused the refineries to extract not only the true gasoline from the crude, but also to carry the process further and take out some of the lower grades of oils.

The result of this inferior fuel which flooded the market was to cause a multitude of automotive difficulties. The engines could not burn the heavier oils properly. Enormous heat was developed which soon burned out bearings and pistons. Starting difficulties in cold weather combined to create confusion throughout the industry.

Conferences were held between the officials of the oil and the automobile industries and steps were taken to remedy the situation. The discovery of new oil fields and better methods of refining alleviated the unsatisfactory state of affairs. Ever since that time the two industries have worked hand in hand.

Increased power can be obtained from a gasoline engine by increasing the compression ratio within certain limits. As the compression is increased the minute molecules of the explosive mixture are forced into closer contact. Consequently, when ignition takes place the time of burning the complete charge is reduced. The sudden burning results in the building up of a higher pressure within the cylinder which in turn delivers more power to the downward moving piston.



Cam Mechanism of "Packard-Diesel"

FURTHER, increased efficiency results from increased compression ratio. The more a charge is compressed the greater will be the percentage of expansion of the gases before the exhaust valve opens. Thus, more useful work is extracted from the gases before they are emitted to the atmosphere.

On the other hand, we know that by compressing a gas we increase its temperature. If the mixture gets too hot auto-ignition will occur, that is, it will be ignited by the heat of compression. Thus, ignition will take place before the desired point and the maximum pressure will be built up before the piston reaches top dead center. This back pressure pushing downward on the piston results in loss of power.

In an effort to obtain increased power and better efficiency the compression ratio of airplane engines has been increased to well over that of those used in automobiles. From 4.0 and 4.5 the compression ratio has gradually gone up to 5.5 and 6.0 for normal uses. The average airplane powerplant can operate satisfactorily under these compression ratios, but above these figures auto-ignition and detonation begin to take place resulting in loss of power, loss of ignition control, and may eventually result, if continued in a badly damaged engine.

By using a blended fuel with non-detonating qualities, however, even high compression ratios may be used successfully and increased powers will be obtained. The addition of tetraethyl lead, more commonly known as ethyl fluid to the fuel will reduce the detonating qualities and permit higher compressions.

A mixture of benzol, a distillate of coal, and gasoline will also prevent detonation. It is this blend which is generally used in racing and high speed engines. The compression ratio of engines used in events such as the Schneider Cup Races frequently goes up as high as 8.0. If special fuels were not used these powerplants would literally blow themselves to pieces. A compression ratio of 10.0 has been successfully used in an internal combustion engine but that is not practical for general usage. Alcohol also makes a splendid non-detonating fuel.

While increased power may be obtained by the use of high compressions we have seen that special fuels must be used. Thus, performance is gained at a greatly increased cost. Other factors also enter into that problem. For instance, high compression engines

operate at a very high temperature. This offers cooling difficulties that frequently lead to trouble. In a previous article we have seen that a sparkplug can be designed to operate well in either a hot or a cold engine, but one plug will not satisfy both conditions. Consequently, if the sparkplug operates successfully under the hot conditions of an engine, it will foul up badly when that engine is idling.

It is thus seen that the high limit of compression ratio for the gasoline engine has been reached so far as practical purposes are concerned. For racing and special purposes, of course, cost does not influence the design so closely.

Two courses are left open to those seeking increased engine performance. One is to develop fuel to a point where it will burn satisfactorily under the severe conditions high compression imposes upon it. The second is to design an engine that will successfully burn the fuels that are already available.

Peculiarly, the second solution of the problem has been in existence for years in the form of the Diesel engine. It takes advantage of the high heat of compression to provide ignition for the fuel. This automatically eliminates the need of a separate ignition system with its added weight, complexity, and many extra parts which might fail. Moreover, extremely high efficiency is gained because of the high percentage of expansion permitted the gases before being exhausted from the cylinders.

This type of engine was first proposed by an eminent German engineer, Dr. Rudolph Diesel, in 1892. Up to comparatively recently the extremely high pressures developed within the engine of this type have demanded that it be constructed of very heavy and strong material. Moreover, burning quite heavy fuel oil, its operating speed has always been low. As used on stationary power plants the weight of the Diesel engine has been as high as one hundred pounds per horsepower. The newly launched German "pocket battleship" uses Diesels which have a weight of eleven pounds per horsepower.

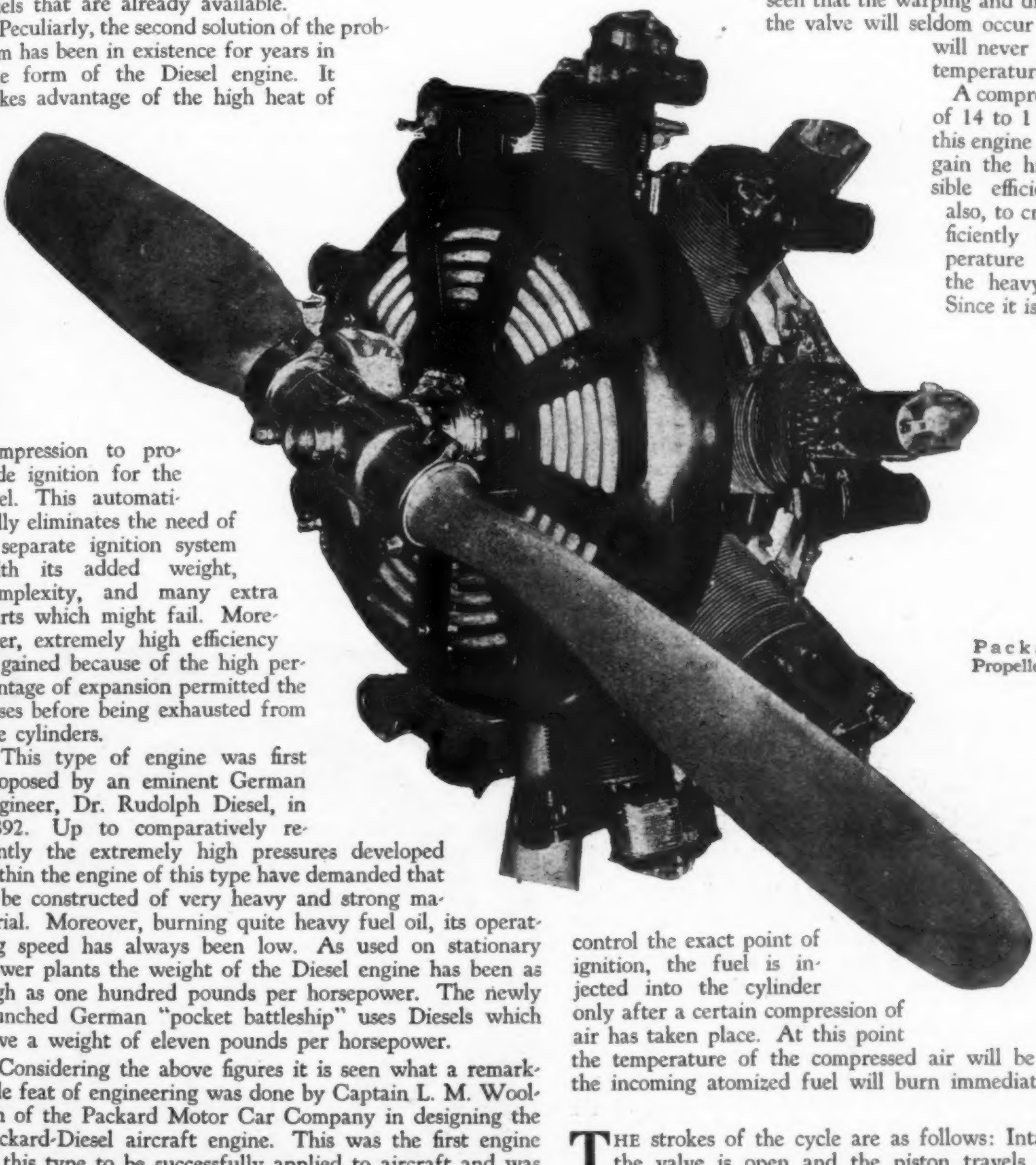
Considering the above figures it is seen what a remarkable feat of engineering was done by Captain L. M. Woolson of the Packard Motor Car Company in designing the Packard-Diesel aircraft engine. This was the first engine of this type to be successfully applied to aircraft and was made possible by the solution of two difficult problems.

The first was the reduction of weight. So ingenious is the design that this engine weighs but 2.31 pounds per brake horsepower—an heretofore unheard of figure. The second problem which was overcome was the modification of the true Diesel cycle sufficiently to permit the attainment of a rotating speed of 1950 revolutions per minute.

The engine is of the nine cylinder radial type of construction. At a distance it might be mistaken for a normal radial internal combustion engine. A closer inspection, however, will disclose that the Packard-Diesel is a cleaner engine. While it has the normal cooling fins they are smaller and less apparent. Also, there is but one rocker arm mechanism and pushrod housing, instead of the two that clutter up the average engine. A coil of copper tubing will be observed around the forward end of the engine behind the shutters. This is merely the lubricating oil cooler.

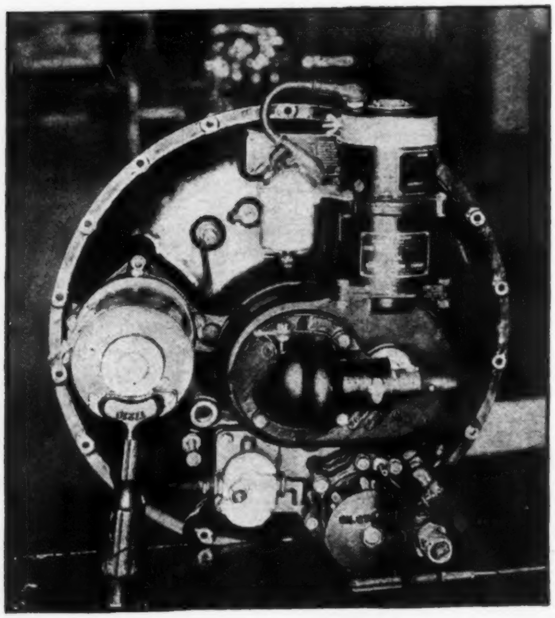
It is to be noted that each cylinder has but one valve. This serves for both intake of air and exhaust for the burnt gases of combustion. Since the cool incoming air alternates with the hot outgoing gases it is easily seen that the warping and distorting of the valve will seldom occur because it will never reach high temperatures.

A compression ratio of 14 to 1 is used on this engine in order to gain the highest possible efficiency and, also, to create a sufficiently high temperature to ignite the heavy oil fuel. Since it is desired to control the exact point of ignition, the fuel is injected into the cylinder only after a certain compression of air has taken place. At this point the temperature of the compressed air will be such that the incoming atomized fuel will burn immediately.



Packard-Diesel, Propeller Mounted

The strokes of the cycle are as follows: Intake stroke, the valve is open and the piston travels downward drawing in a charge of pure air. The valve remains open until the piston is 25 degrees after bottom dead center. We have seen that the inertia of the inrushing air will keep a flow of air into the cylinder for some time in spite of the piston's change of direction. This will increase the



Starter Mechanism

volumetric efficiency considerably.

As the piston continues to travel upward on the compression stroke the entrapped air is compressed. When 45 degrees before top dead center the pressure will be about 600 pounds and the temperature of the air will have been raised to approximately 1000 degrees F. At this point the fuel oil is injected into the cylinder under a pressure of about 400 pounds per square inch. Forced through a tiny nozzle the oil is completely atomized. It now mixes thoroughly with the turbulent compressed air and combustion takes place at once. The oil is not forced into the cylinder all at once. Instead, it continues to be sprayed in until just after the piston goes over top dead center on the power stroke.

As the fuel burns it creates a pressure in addition to the further compression built up by the piston as it continues upward. Thus, as the piston begins its power stroke a maximum effective pressure of 1200 pounds is reached. Compare this to the 550 pounds peak pressure of the Otto cycle engine.

Because of the high compression ratio the gases of the Diesel engine will have expanded a greater percentage by the time the valve opens for exhaust than those of the gasoline engine. The exhaust point is set at 45 degrees before bottom dead center.

The piston continues on to the end of its stroke and then returns upward, driving the burnt gases out of the valve. Since this valve is also the intake valve it does not close at the end of this stroke, but remains open and the down traveling piston again draws in a fresh charge of air. It is to be observed that the valve movement has been reduced materially thus again reducing the possibilities of troubles.

It was essential for Captain Woolson to reduce the weight of the Diesel engine if it were to compete with the light Otto cycle engines. In spite of this difficult requirement he had to design his engine to take care of the tremendous peak pressure of 1200 pounds. To do this he used magnesium liberally. This metal is but one-half the weight of steel and has approximately the same strength.

In addition to light materials, skillful methods were devised for constructing the engine. Particularly is this true of the means used for securing the cylinders to the crankcase.

The cylinders are forged from chrome-molybdenum steel. The steel cooling fins are machined from the same stock as the barrel. The head is integral with the rest of the cylinder and the entire construction is exceedingly strong. As only one valve opening need be made in the head this also lends to the strength of the structure. On the exterior head is bolted an aluminum foundation for the single rocker arm and the valve housing.

THE crankcase is a single casting of magnesium which weighs but thirty-four pounds complete. A peculiar feature of this metal is its ability to stand enormous compression, and at the same time lacking tensile, or pulling strength. Taking this fact into consideration, it certainly would be unwise to bolt the individual cylinders to the crankcase by studs as is ordinarily done.

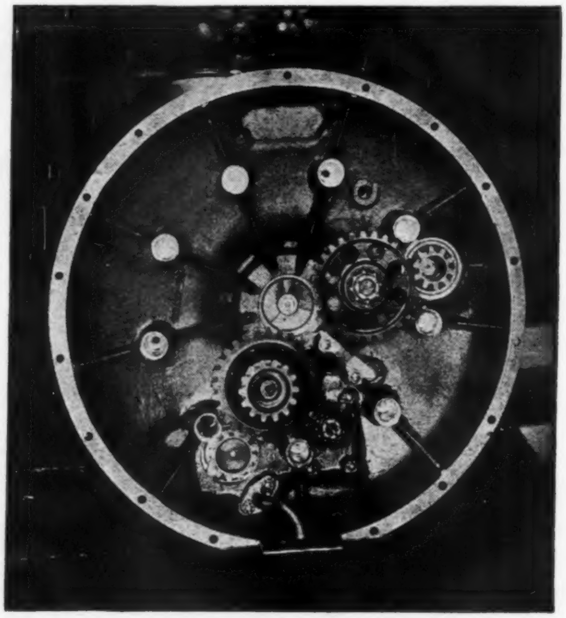
Each explosion within the cylinder would be a tremendous strain upon the thin walls of the crankcase which would eventually rupture and break apart. The cylinders would tend to blow off from the crankcase at each explosion.

Captain Woolson forged a hold down lug on the forward and after side of each cylinder. The nine cylinders are set in place and a three-quarter inch steel hoop passed around the hold down lugs on the front of the engine. A second hoop is passed around the lugs aft. Each hoop is made in three sections joined together by turnbuckles.

By means of long handled wrenches the turnbuckles are placed under a heavy strain. Thus, all nine cylinders are held to the circular crankcase by means of the tightened steel rings. The crankcase is placed under so much compression that even the high pressures of combustion cannot place a tensile strain upon it.

Another factor which enters into the crankcase construction can best be compared with the wire spoked automobile wheel. Here the hub is kept from touching the ground by the tensile stresses set up in the spokes in the upper sector of the wheel. These spokes are secured to the rim which in turn keeps the entire wheel off the ground.

Likewise, in the Packard-Diesel engine, as the explosion takes place in one cylinder the steel hoops transmit the tensile load to the opposite side of the crankcase where it is converted into compression between the hoops and the bearing anchorages. This type of stress can be easily with-



Crank Case Housing; Propeller End

stood.

A single fuel pressure pump is used for each cylinder. This is a small piston plunger pump the length of stroke of which determines the amount of fuel that is forced to enter the cylinder. Since the amount of fuel is the factor determining the speed and consequently the power the engine will develop, the pump stroke must be controlled by the throttle. Actually, the throttle rotates a control ring to which is linked up arms which regulate the length of the pump stroke.

The pump pistons are actuated by a revolving cam geared directly onto the crankshaft. As a lobe of the cam reaches the pump unit it raises a cam follower which in turn pushes up the piston inside the small pump cylinder. The pump unit will deliver the fuel oil into the cylinder under a pressure of from four to five thousand pounds. This insures good atomization and a resulting complete and quick combustion.

Diesel, showing Oil Cooling Coil of Copper Tubing

The fuel is fed into the individual pumps by means of a fuel line which encircles the rear of the engine. A pressure of ten pounds is maintained in this ring by means of an ordinary gear fuel pump.

THE external inlet of the single valve opens into a venturi. The intake air goes to the cylinder through the forward end of the tube while the exhaust gases escape through the after end. An air shutter or flapper valve is inserted in the forward end of the venturi in order to restrict the air when using idling speeds.

This is necessary because it is difficult to inject the minute amount of fuel that would be necessary to give idling speeds. Idling can be accomplished, however, by limiting the amount of oxygen in the cylinder which is available for combustion. As the throttle is closed the flapper valves are automatically closed in the proper proportion. It is obvious that idling speed is uneconomical.

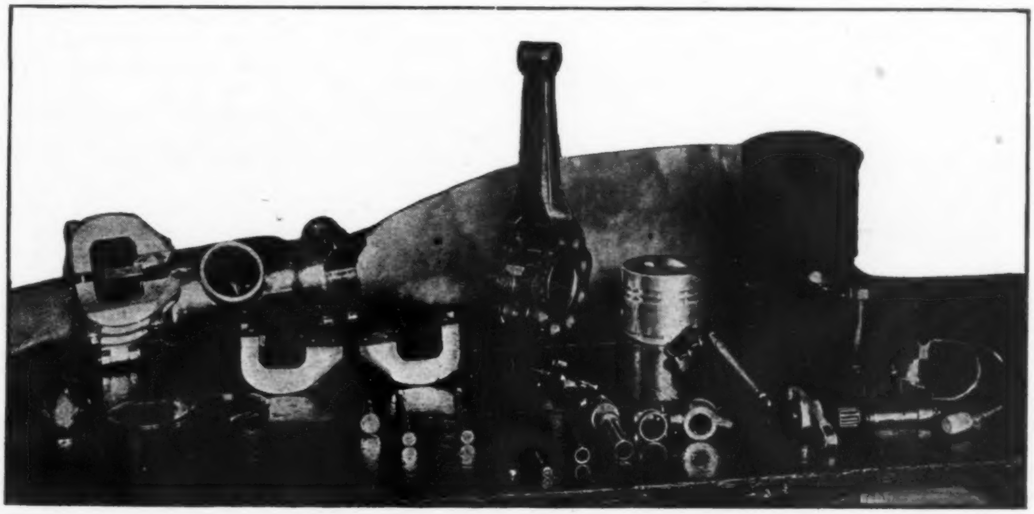
To insure complete burning and its resulting efficiency it is necessary to have a surplus of air. The Packard-Diesel provides twenty-five per cent excess amount of air at sea level. Of course, as the plane climbs and the air density decreases, this surplus will be reduced.

As a matter of fact the altitude at which the amount of oxygen equals the combustible need of the fuel is 8000 feet. It is thus seen that the engine retains its sea level power up to this height. This factor gives a certain degree of supercharger benefits.

This piston is of normal shape except it has an indentation on one side. Because of the high compression ratio there is very little clearance volume. Consequently, it is necessary to provide this depression in order to permit the valve to open.

Besides, this construction provides the maximum turbulence to the compressed air. In addition, the air is admitted tangentially in order to further obtain turbulence which results in quick and complete combustion.

Because of the high peak pressure this engine might be rough in its operation except for two ingenious schemes. First, the counterweight of the crankshaft is mounted on a pivot and rides against two large springs. As the peak pressure begins to move the piston at a rapid acceleration, the springs permit the counterweight to lag behind. When the piston pressure is reduced further along in the cycle the compressed springs return the counterweights to their original position. This tends to equalize the crankshaft speed. *(Continued on page 31)*

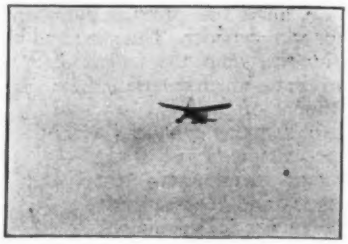


A few of the parts that make up the assembly of the Packard-Diesel

The Clark Cabin Model

Instructions and Plans for Building an Unusual Flying Plane

By Jack Clark



"Out of the West"
The Clark Model in full flight at Portland, Oregon

IN THIS article we shall describe the construction of a very light and rugged model that has good altitude and distant qualities as well as easy landing ability.

Its features are sheet balsa wheel pants, demountable nose and tail plugs instead of a motor-stick, three-unit wing construction, and a split-axle landing gear that spreads when the plane lands.

You will require the following material for this model:

Material. Where Used.

1 piece balsa, 1/32 x 1/16 x 12. Window molding, tail bracing.

2 pieces balsa, 1/16 x 1/16 x 24. Fuselage bracing, tail and rudder.

1 piece balsa, 1/16 x 3/32 x 30. Front fuselage bracing, rudder.

3 pieces balsa, 1/16 x 1/8 x 36. Wing spars and edges, tail, rudder, etc.

1 piece balsa, 1/16 x 3/16 x 30. Wing main spar, tail center rib.

5 pieces balsa, 3/32 x 3/32 x 36. Fuselage longerons, cross-bracing, etc.

1 piece balsa, 1/8 x 1/8 x 2½. Landing gear strut hinge blocks.

1 piece balsa, 1/8 x 1/4 x 4. Hanger support, cabin edge, tail skid.

1 piece balsa, 3/16 x 3/8 x 2. Wheel pant sides spacers.

1 piece balsa, 1/4 x 1/4 x 13/16. (Tail plug.)

1 piece balsa, 3/8 x 7/16 x 1. (Tail plug.)

1 piece balsa, 1/4 x 1 1/16 x 1¼. (Nose plug.)

1 piece balsa, 1/8 x 1 1/16 x 1 9/32. (Nose plate.)

1 piece balsa, 5/8 x 1 x 7½. (Propeller block.)

1 piece balsa, 1/16 x 1½ x 30. All parts specified 1/16 sheet.

1 piece balsa, 1/32 x 3 x 24. All parts specified 1/32 sheet.

2 pieces bamboo, 1/16 x 1/4 x 15. All parts specified bamboo.

1 piece pine, 1/16 x 1/8 x 2. Axle guide.

One ounce bottle of colorless airplane cement.

One ounce bottle of wing dope (50% nitrate dope, 50% acetone).

2 sheets "Superfine Japanese tissue," 18 x 21.

1 sheet, medium weight rice paper. (About 5 x 9.) For nose 40 inches of No. 10 music wire (.024"). For all wire parts except "e" small piece of No. 8 music wire (.020"). For hanger brace "e" only, on nose plug. (Drawing No. 1.)

6¼" diameter washers. To fit No. 10 wire for wheels and propeller shaft.

2 thrust bearings, steel. (Refer to Drawing No. 1 for sizes.)

1 thin piece of tin or brass, ¼ x 1 1/16. Bearing plate for rear or propeller hub (Drawing No. 6).

1 piece of 3/32 outside diameter brass tubing. For propeller shaft (Drawing No. 6.)

2 No. 3-0 "Wilsnap" dress snaps. For snapping nose plug to fuselage (Drawing No. 1.)

90 inches (7½ feet) ⅛ flat rubber motor. For 3 loops (6 strands), 15 inches long.

1 piece of cellophane, 9/16 x 1 15/16. Front cabin window. (W-1 on Drawing No. 1.)

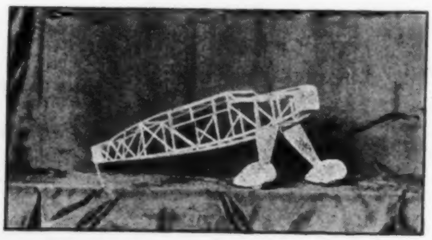
2 pieces of cellophane, ⅞ x 5. For the four side windows on each side of fuselage. (W on Drawing No. 1.)

Fine silk thread. For binding where specified.

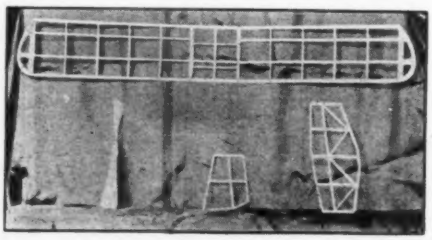
Many dimensions are omitted from the drawings as they are full-size. Measurement with a ruler will determine any desired dimension.

As most of the parts of the model are of balsa wood, all parts referred to in either the article or on the plans are understood to be of balsa (medium-hard), unless otherwise specified.

The original model was finished with yellow dope on body, landing gear struts, surfaces and pants, with black trim around strut edges, pant sides and cabin. The nose



The Fuselage skeleton, ready to cover



Wing, Stabilizer and Fin framework finished "Pro p"

and propeller was silver.

Finish, of course, is optional with the individual builder. We shall start first with the fuselage.

Fuselage

The fuselage, like the other parts of the plane, is shown full-size, and so the plans or tracings of them can be used directly as assembly patterns.

Pin drawings No. 1 and No. 2 or their tracings together upon a smooth board so that the top and side views of the fuselage are shown as one continuous layout. With a razor blade, cut to the sizes and angles the balsa pieces for the body sides and for the top and bottom cross-pieces. Lay wax paper over the plans to prevent glue sticking to them and then form a jig by driving pins or small finishing nails around the side and top views to hold the parts in place.

Set all the pieces for one side in the form except the diagonal marked "assemble last." Cement all joints and allow 30 minutes to set, then lift out frames and build up other side.

Next make the nose plate *g*, nose plug *h* and hanger support *h*-1. (The hanger support is cut from the 1/8 x 1/4 x 4 piece given in the material list). The rest of this 4-inch piece is cut and sanded to size for the 3/32 x 1/4 x 2 top front cabin edge, and the 3/32 x 3/16 tail-skid base. See Drawings (No. 1 and No. .2)

Bind and glue two steel hangers or thrust bearings of the dimensions shown, to the support *h*-1. At this point in the construction form the U-shaped hanger-brace *e* of No. 8 music wire and imbed into, and cement to, the front of the nose plug *h* in the position shown on Drawing No. 1. This will prevent the front hanger from bending back into the slot under an impact on the nose.

Now insert and glue the support *h*-1 into the slot in the nose plug. (Note: The rear hanger is made longer than the front one so that the propeller shaft will set at a negative or downward angle. The line of thrust being down slightly will prevent the plane from stalling under power with the wing ahead in a good gliding position. If the model stalls *on the glide*, the rear hanger can be bent slightly back to a lower position, thus reducing the shaft angle.)

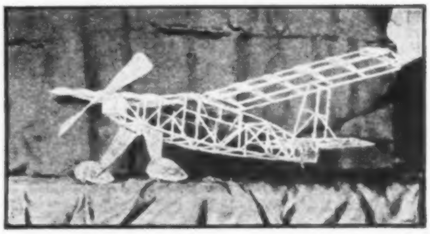
Cement halves of two No. 3-0 "Wilsnap" dress snaps onto the nose plate, and cement the other halves to the nose plug as shown. A neater fit can be made if you cut out slight circular depressions in the balsa to receive the snap halves.

Cut two pieces of cellophane (see material list) to fit the four window sections at the top of the body sides, marked "W," and cement to the sides so that the cellophane will be on the inside of both body sides when the fuselage is assembled.

Set the two side frames in the top view form and glue in place the middle bottom cross-pieces. Push the back of the structure down against the drawing, and glue in place the rear braces. Then reverse the frame on the plan and glue in the middle and rear top pieces in the same manner, including the 3/32 x 1/4 cabin edging which is sanded off to a smooth rounded edge, after taking from form.

Next cement the front ends of the longerons into the grooves in the nose plate and wrap with thread to hold in place until dry. When set, remove the thread and insert upper and lower front cross-pieces, checking their position

An Interesting Model to Build, and One Which Will Reward You With Excellent Flights



The completely assembled skeleton

with a ruler. Now glue in the diagonals marked "assemble last." Cut out and notch the cowl formers *a*, *b* and *c* and the cowl stringer *d* and cement in place as shown. (Note: Do not overlook cementing in the four 1/16 x 3/8 sheet balsa pieces all around the nose right back of the nose plate as these greatly aid in resisting headon shocks in flight.)

Form the can *f* for the rubber motor and glue and bind it to the 3/32 square x 2 piece as shown. Cement this unit to fuselage at the point indicated. This "can" will prevent undue vibration by keeping the rubber from thrashing around while unwinding.

Our next step on the body is to make the landing gear fittings of No. 10 music wire. After bending to shape, cement and bind with fine silk thread to the bottom longerons in the exact position shown on the drawing. The thread binding is very important at these joints. Be careful to get all four fittings evenly located from the front end of the body.

Make the wing-rubber grips of No. 10 music wire and cement to the fuselage at the points shown. The rear grips should be bound with thread about the bottom cross-bar at which they are located.

Cut a piece of cellophane to fit over the front window space marked "W-1" on the plan or top view, and cement in place. When dry, glue on over the cellophane a molding of 1/32 x 1/16 strips.

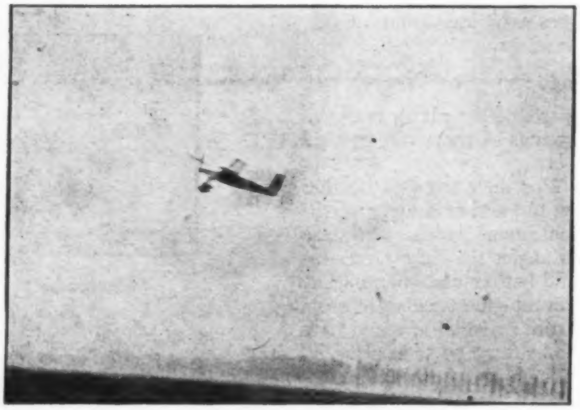
Referring now to Drawing No. 2, make up the tail plug and its wire fittings as shown; also the tail-skid which is cemented to the 3/32 x 3/16 base on the bottom of the fuselage.

Before covering the fuselage, glue in place the landing gear axle guide (see Drawing No. 3 and text on landing gear). When ready to cover body proceed as follows: Cover both sides of the fuselage from the nose plate to the door outline with a medium weight rice paper; also cover the top from the nose plate to the window with the same weight paper. Cover the first three panels of the bottom with rice paper, carefully sealing the space around the protruding pine pieces of the axle guide. (See landing gear details, Drawing No. 3.) Using a heavier paper on the nose helps strengthen the front of the plane. Heavy—that is, "straight"—wing dope makes a fine paper cement and produces a neat job. However, straight dope thinned with 50% of acetone works very well if you apply the paper to the frame a section at a time and work quickly.

Cover the rest of the fuselage with "Superfine" tissue

and apply a coat of light dope to all body surfaces after trimming the paper edges off with a razor blade. A coat of silver dope on the nose and black trimming around the windows adds a great deal to the appearance of the fuselage.

Finally cement four (1/16 square x 2) "wing strip" pieces to the top of the body just back of the front window. These strips are shown on the side elevation of Drawing No. 1, but not on the top view. Space these pieces 3/32" apart. The angle of incidence piece on the leading edge of the wing (Drawing No. 5) fits between them and they keep the wing from sliding back along the body during flight.



Gaining altitude after the "take off"

Landing Gear and Pants

With a razor blade cut out the struts from 1/32 sheet. Cut so the grain runs parallel with the front edge of the strut. The strut is notched out at its bottom so the thread binding of the axle will not slip. Drawing No. 3.

Next cut out the thin bamboo braces and the small balsa strut pieces and glue them to the struts. Have the glossy side of the bamboo away from the balsa. As one strut will be left and one right, the braces must be glued to the opposite side of one strut with respect to the other strut. With a very sharp razor blade cut to size from 1/8 square balsa the hinge blocks shown on the plan at the top of the strut.

Bend the No. 10 music wire hinges and insert into the blocks. Cement the hinges to the blocks and bind with fine silk thread; then cement the blocks to the struts, locating them very carefully in their proper positions.

Form the No. 10 music wire axle, and glue and bind to each strut as shown. Note how the center part is bent to slide in the axle guide—form this part accurately to the plan so it will not bind or be too loose when assembled in the guide. Cover the inside of each strut with "Superfine" tissue to streamline, and dope lightly.

We shall now make the pants. From 1/32 sheet cut out four pant sides to the inside outline on the side view on Drawing No. 3. Punch a hole for the axle with a piece of No. 10 wire through each side piece at the point shown on the drawing. Cut to size the side spacers (*a*), (*b*), (*c*), (*d*) and (*e*), two of each. Glue each (*a*) piece between two pant sides in the front position shown. After the cement has set, glue in the rear spacers (*e*) and hold in place with thread lashing until dry. When the rear pieces have set, remove the thread and insert in place and cement the spacers (*b*), (*c*) and (*d*).

Now prepare the covers for the pants by cutting out pieces (*g*) from 1/32 sheet, making them slightly wider than the size required as indicated on the drawing. Cut them out so the grain runs *cross-wise*, that is, at right angles to the pant sides. Although you will probably have to use more than one piece to cover the top this way, it will enable you to bend and glue the pieces around the curve of the pant much more easily and smoothly.

After glueing on the cover pieces, trim flush to the sides with a razor blade and then sand all edges smooth with fine sandpaper. (Note: You will have to glue on the bottom pieces after the wheels have been assembled.)

Now cut out two (1/16 x 1/8 x 1/4) pant pieces and cement one to each pant (opposite respective sides, of course) exactly 7/8" in from the front end of the pant and 7/32 down from the top of the pant. Cut out the 1/16 x 1/4 x 3/8 pants-to-strut braces and bevel their ends to match the front end view of the pant assembly on the drawing. Cement them to the pants and lay away to dry.

Glue a small 1/4" diameter washer to each side of each wheel at the hub. (1 1/4" is the proper wheel diameter for this pant size.) Apply two coats of wing dope to the wheels to strengthen them and then slip one of the wheels into a pant and run the pant and wheel onto the axle together. Now glue the beveled projecting end of the pant-to-strut brace to the landing gear strut snug under the 1/16 x 1/8 x 1/4 piece on the strut as shown in the front pant assembly view. Be sure the pant assembly lines up squarely with the strut. Proceed likewise with the other wheel and pant and then glue on the bottom pieces of the pants.

Our next step is making the axle guide and support. Cut from 1/16 sheet balsa the web and triangle horizontal braces shown in the detail of the axle guide and glue them together to form the support. Prepare the pine pieces for the guide from the (1/16 x 1/8 x 2) pine piece given in the general material list and glue the two 7/8" long pieces to the support; the bottom piece is cemented on the last thing after assembling the axle in the guide.

Take the fuselage and carefully locating the guide support in its proper position in the bottom of the body, cement it in place. See Drawing No. 1.

Now bend the hinging pins and then carefully pin in place the struts to the fuselage. Slip the center of the axle between the two guide pieces and spread the wheels with the fingers to test the spring in the axle. Last, glue on the small 3/8" long pine piece onto the bottom of the guide. This completes the landing gear.

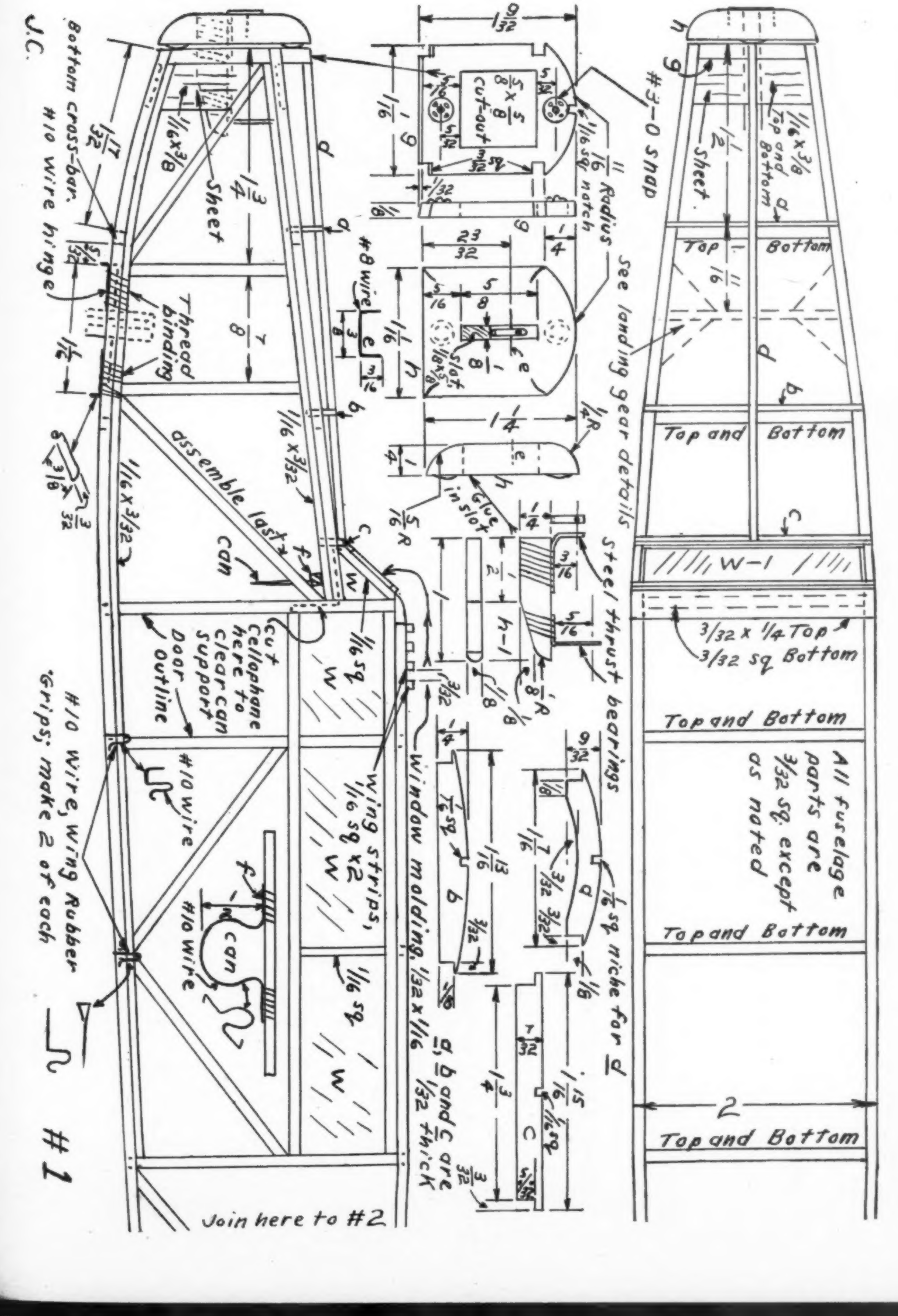
Stabilizer and Rudder

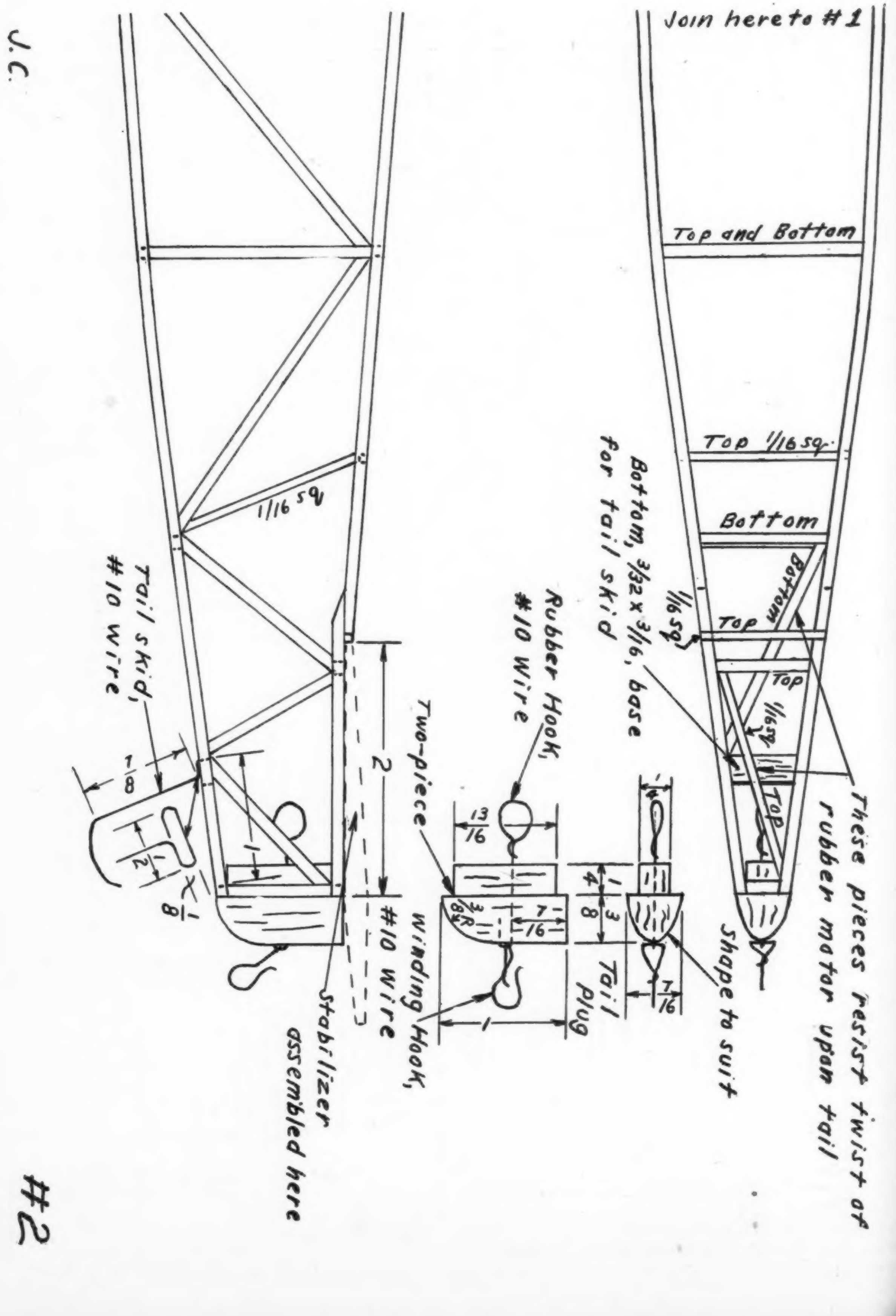
The plans of the tail and rudder are shown full-size on Drawing No. 4. Notch and assemble the ribs and ends to the spar first. Then splice the leading edge, and glue that and the trailing edge in place. True up and allow to set. Next sand the ribs and spar ends to a taper and then glue in place the diagonals and small blocks shown.

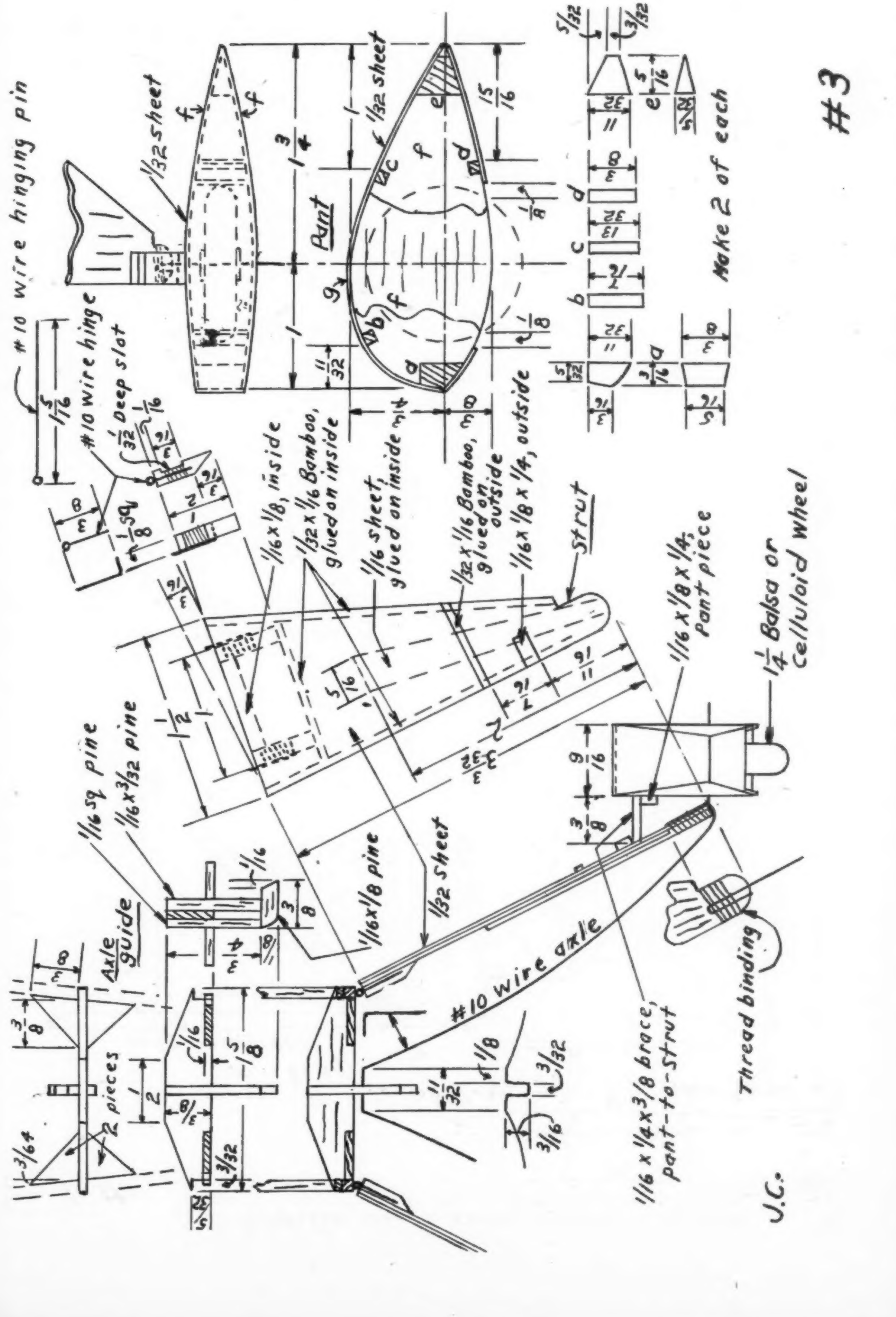
The small (1/16 x 1/8 x 1/4) pieces at the center rib make a more solid foundation for glueing the stabilizer to the body, while the (1/16 square x 1/4) pieces form a place to receive the ends of the 1/32 round bamboo rudder braces without weakening the spar. The diagonals reduce warping tendency when the tail is doped or later subjected to weather changes.

The stabilizer is covered on both sides with "Superfine" tissue and treated with a coat of light dope. Black India ink lines drawn on the top and bottom of the tail along the spar line improve the appearance by representing the flippers or elevators.

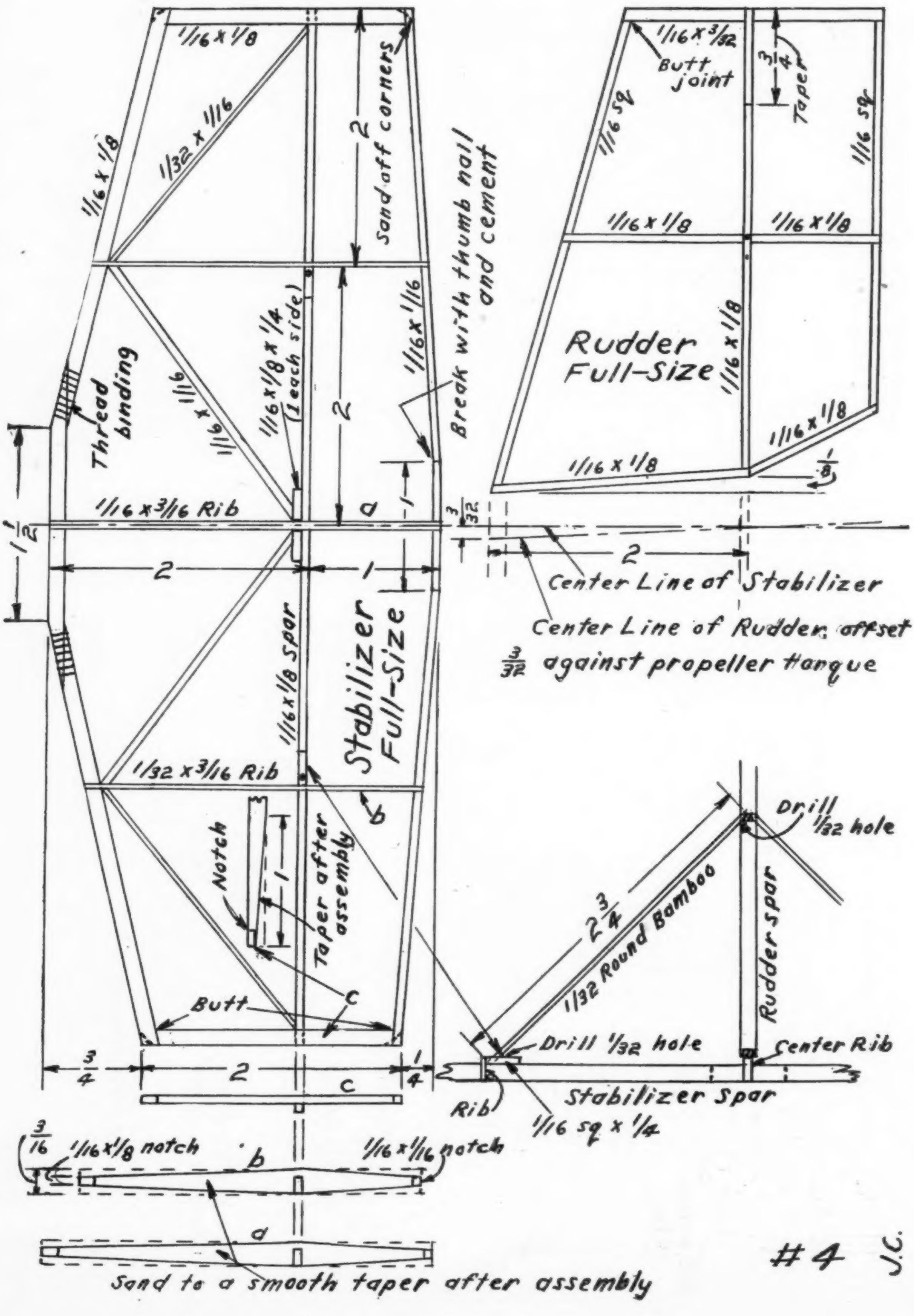
The rudder is built up in a manner similar to the tail; however, in making the rudder it is better to drive pins around the drawing or its tracing and insert the parts in the form before cementing them together, as was done with the fuselage. The middle (*Continued on page* 22)

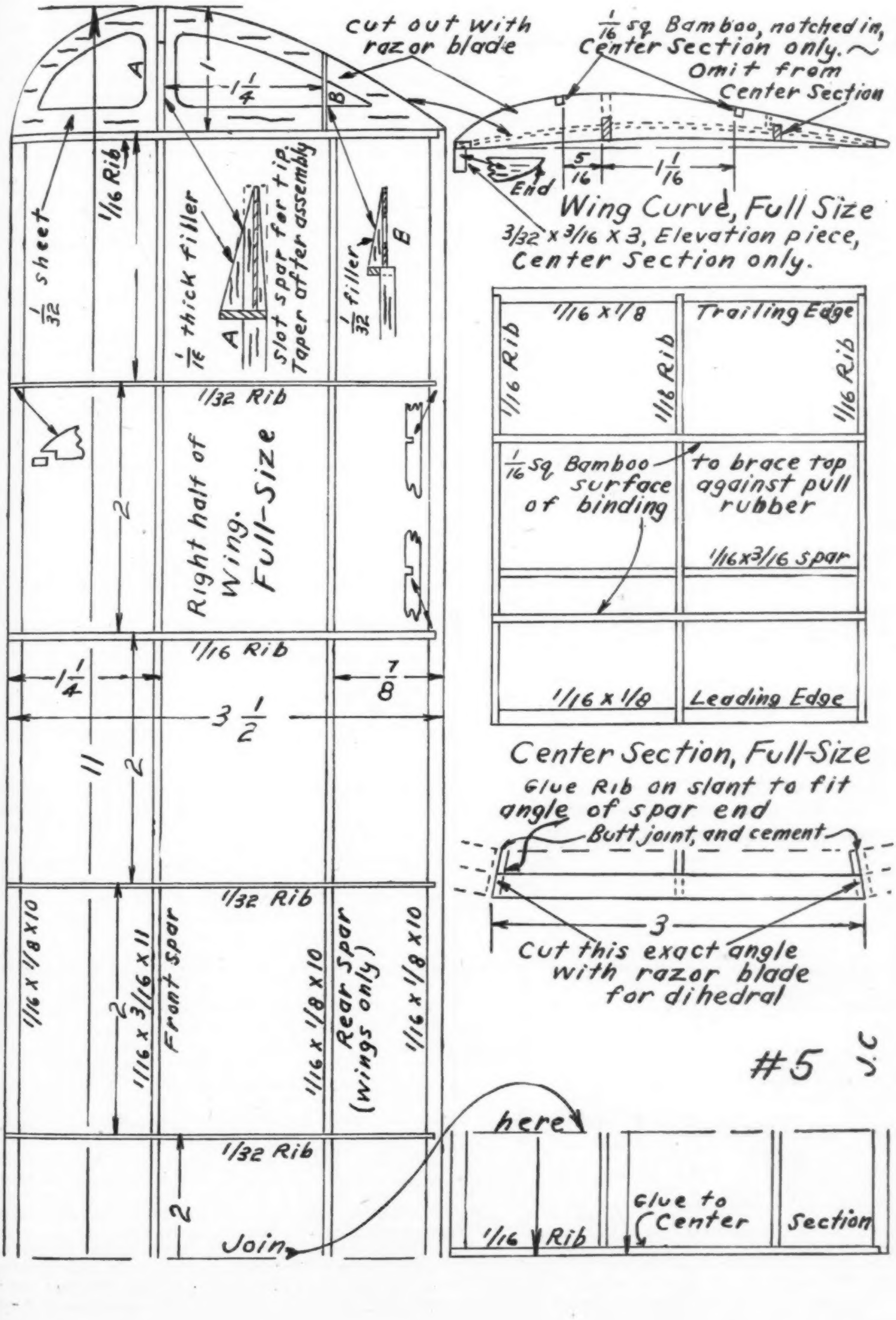

J.C.
Bottom cross-bar.
#10 wire hinge
Sheet
Thread binding
assemble last
can
Cut Cellophane here to clear can support
Door outline
#10 wire
#10 Wire, Wing Rubber 'Grips', make 2 of each
#1
Join here to #2
wing strips, 1/16 sq x2
window molding, 1/32 x 1/16
a, b and c are 1/32 thick
#8 wire
Glue in slot
cut-out
#3-0 snap
Radius
1/16 sq notch
see landing gear details
steel thrust bearings
1/16 sq niche for d
W-1
Top and Bottom
3/32 x 1/4 Top
3/32 sq Bottom
All fuselage parts are 3/32 sq. except as noted

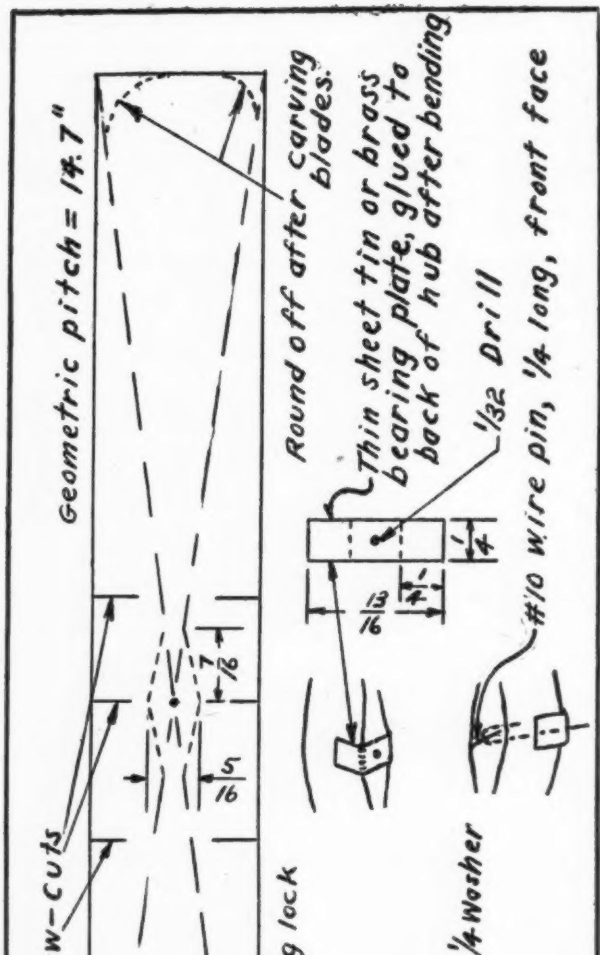

J.C.
Join here to #1
Top and Bottom
Top 1/16 sq.
Bottom
Bottom
Top
1/16 sq.
Top
1/16 sq
Top
These pieces resist twist of rubber motor upon tail
Shape to suit
7/16
Tail plug
1/16 sq
Bottom, 3/32 x 3/16, base for tail skid
Rubber Hook, #10 Wire
13/16
Two-piece
1/4
3/8
3/8 R
7/16
1
Winding Hook, #10 Wire
2
Stabilizer assembled here
Tail skid, #10 Wire
1/8
1
1/2
1/8
#2



#10 wire hinging pin
#10 wire hinge
1/32 Deep slot
1/32 sheet
Pant
1/16 x 1/8, inside
1/32 x 1/16 Bamboo, glued on inside
1/16 sheet, glued on inside
1/32 x 1/16 Bamboo, glued on outside
1/16 x 1/8 x 1/4, outside
Strut
1/16 x 1/8 x 1/4, Pant piece
1 1/4 Balsa or Celluloid Wheel
Thread binding
1/16 x 1/4 x 3/8 brace, pant-to-strut
#10 wire axle
1/32 Sheet
1/16 x 1/8 pine
1/16 sq pine
1/16 x 3/32 pine
Axle guide
2 pieces
Make 2 of each
#3
J.C.


1/16 x 1/8
1/32 x 1/16
1/16 x 1/8
Sand off corners
2
Break with thumb nail and cement
1/16 x 1/16
1/16 x 1/8 x 1/4 (1 each side)
Thread binding
1/16 x 1/16
2
1
1 1/2
1/16 x 3/16 Rib
a
3/32
2
1
1/16 x 1/8 Spar
Stabilizer Full-Size
1/32 x 3/16 Rib
b
Notch
1
Taper after assembly
Butt
c
3/4
2
1/4
c
1/16 x 3/32
Butt joint
3/4
Taper
1/16 sq
1/16 sq
1/16 x 1/8
1/16 x 1/8
Rudder Full-Size
1/16 x 1/8
1/16 x 1/8
1/16 x 1/8
1/8
2
Center Line of Stabilizer
Center Line of Rudder, offset 3/32 against propeller torque
Drill 1/32 hole
2 3/4
1/32 Round Bamboo
Rudder spar
Drill 1/32 hole
Center Rib
Rib
Stabilizer Spar
1/16 sq x 1/4
3/16
1/16 x 1/8 notch
b
1/16 x 1/16 notch
a
Sand to a smooth taper after assembly
#4
J.C.


cut out with razor blade
1/16 sq. Bamboo, notched in, Center Section only.~
Omit from Center Section
A
B
1 1/4
1
1/32 sheet
1/16 Rib
1/16 thick filler
Slot spar for tip. Taper after assembly
1/32 filler
A
B
End
5/16
1 1/16
Wing Curve, Full Size
3/32 x 3/16 x 3, Elevation piece, Center Section only.
1/32 Rib
Right half of Wing. Full-Size
2
1/16 x 1/8
Trailing Edge
1/16 Rib
1/8 Rib
1/16 Rib
1/16 sq. Bamboo surface of binding
to brace top against pull rubber
1/16 x 3/16 spar
1/16 x 1/8
Leading Edge
1/16 Rib
1 1/4
7/8
3 1/2
11
2
Center Section, Full-Size
Glue Rib on slant to fit angle of spar end
Butt joint, and cement
3
Cut this exact angle with razor blade for dihedral
1/32 Rib
1/16 x 1/8 x 10
2
1/16 x 3/16 x 11
Front Spar
1/16 x 1/8 x 10
Rear Spar (wings only)
1/16 x 1/8 x 10
#5
J.C
here
1/32 Rib
2
Join
1/16 Rib
Glue to Center Section



(*Continued from page* 16)

vertical spar is notched at one end to receive the top edge piece, after which the spar is tapered 3/4", from the top out to the end. The middle horizontal rib is made of two pieces butted against each side of the spar and notched at their ends for the leading and trailing edges. After the complete rudder assembly they and the bottom rib pieces are tapered with sandpaper from the vertical spar out to the leading and trailing edges. The bottom pieces are notched and assembled the same as the center rib pieces.

Cover the rudder in the same manner as the stabilizer and paint or ink the spar line "black," on each side for the rudder hinge line.

Sand away carefully the paper on top of the center rib of the stabilizer and cement the rudder to the tail, offsetting it 3/32" as shown on the drawing.

Shave and sand to size the bamboo rudder braces. Drill a small hole in the rudder spar on each side where the middle rib comes and drill holes in the small blocks on the tail by the middle ribs. Cement the bamboo braces into these holes, being careful to have the rudder as near perpendicular to the tail as possible.

Sand away lightly the covering on the bottom of the spar where it joins to the body and glue the tail and rudder unit to the fuselage, butting the leading edge of the stabilizer flush against the 1/16 square piece on top of the body. See Drawing No. 2. Be sure the stabilizer is square with the body.

Wing

The wing consists of three parts: The center section, the right half and the left half. The high-lift ribs are cut from 1/32 and 1/16 sheet and the spars and edges are notched into them. Drawing No. 5.

The spars of the center section are cut at an angle at their ends and the two outer ribs cemented on at an angle so that when the halves of the wing are glued to the center part they will form with each other the necessary dihedral for stability.

After building up the two halves and center section of the wing, apply a liberal coat of cement to the inner rib of one of the halves and cement and bind with strong linen thread to the center section. Run pins into the ribs so they will not slip out of line while being wrapped. Do the same with the other wing half, and when the cement has set remove the pins and thread.

Cover the top of one wing with "Superfine" tissue, using wing dope to stick the paper to the frame. Work from the inner rib out, doping each rib one at a time and rubbing the paper down until it sticks. After the paper has been stuck to all ribs and the tip, dope the outside of the edges a section at a time and stick down the paper. Trim with a razor blade and apply one coat of light dope. Weight down around the edges for 30 minutes while the dope is drying. Then proceed likewise with the top of the other half of the wing and the top of the center section. Next cover one side on the bottom, dope and weight down, and then cover the other bottom side and center section, and dope. (Note: While the under surfaces are drying they should be raised up on books or boards so the air will circulate under the wing.)

After covering, cement on the (3/32 x 3/16 x 3 elevation or angle of incidence piece to the under side of the center section leading edge. Sand away lightly the paper so the cement will hold to the wood of the leading edge. You can use two pieces of 3/32 square glued together to form this elevation piece.

Paint a black line, top and bottom, around the line of the rear spar, trailing edge and rear portion of the end rib, and the rib second from the end one, on both wing halves. This marking represents the (*Continued on page* 47)

Frank Luke, Jr.

"The Balloon Terror"

The Miner of Arizona Who Became America's Second War Ace

By J. Noble

HAVE you ever wondered what would happen if the famous "bad men" of the Wild West had lived at the time of the Great War? Here is the story of a modern Jesse James and Buffalo Bill rolled into one death-defying airman.

Frank Luke, Jr., born in Prescott, Arizona, went almost directly from the football gridiron to the battle fields of France. Three months after he landed at Brest as a rookie pilot in the A. E. F., he died, far behind the German lines, in the riddled cock-pit of his bullet-shattered plane.

Yet thrilling as are the adventures of this modern "Bad Man" of the West, who rode a Spad instead of a broncho, the history of his boyhood and early youth in the wild desert regions of Arizona and Texas is almost equally exciting. Luke's German parents emigrated to Arizona shortly after the Civil War, and there, among the wild scenes of mining boom towns, in the last flaring days of the Open Range, Frank Luke spent his earlier years. Straddling a horse almost as soon as he could walk, Luke found in his favorite diversion of hunting, the gun practice which was later to enable him to shoot down 14 balloons and 4 planes in the space of only 17 days.

From earliest childhood this future ace carried the hearty respect of both friends and foes, and even among the hard-boiled denizens of the Arizona Bad Lands he was early known for the quality of his unflinching bravery and blazing independence. At the age of 16, Luke's fighting fame had already spread throughout his own town of Prescott. Soon it was to cover the entire state of Arizona, when as "the copper mining kid" he knocked out the professional pugilist, Battling Haney, in the first round of an exhibition fight. Only a few weeks after this exploit he won further praise for his Indian-like grit, by playing through the last quarter of a high school football game with collar bone broken, and right arm dangling helplessly at his side.

THOUGH Frank Luke was to become America's second greatest War Ace and the only flier in the war to receive the Congressional Medal of Valor, he showed no interest in aviation up to the time of America's entry into the World War. In fact, so little did Luke know of, or care for, the principles of aeronautics that once he tried to jump from the cupola of his high school building, using only a wagon umbrella for a parachute.

It is easy to see that a man of Luke's restless, battle-loving character would be among the first to enlist in those stirring days of September, 1917, when the first call for volunteers went out from Washington. Following his enlistment Luke received an immediate assignment for active duty at the Ground School in Austin, Texas. Joining his class late, he nevertheless graduated with the others, and was ordered to Rockwell Field in San Diego, Calif., for actual flight instruction. Yet, three months of army discipline had done little to break Luke's spirit of independence, for, upon being sent up for his first solo flight, Luke was seen to execute a "Falling leaf" and "double loop." His success with these maneuvers did not soften his instructor's anger, and he was grounded for three days. Luckily, he was forgiven in time to sail for France with his unit as a Second Lieutenant, on March 18th, 1918.

As though fate were following his every footstep, the eager Luke was again balked in his desire to get into immediate action. From the time of landing in early April, until his assignment to the First Pursuit Squadron in July, Luke was either kept on the ground, or used for such tame, but to him tantalizing, service as ferrying planes to the battle front and leading practice formations far behind the lines.

Once he found himself within hearing of German guns, Luke lost little time in distinguishing himself as a fighter. On his first flight with the 27th Aero Squadron, of which he was a part, Luke deserted his formation and reconnoitered alone. The following day, despite the stern warning of his commander he deserted again, and sped far afield over the German lines. This time upon returning to the official reprimand which he knew awaited (*Continued on page 41*)

Special Course in Aerial Radio

The Battery—Shielding

By Capt. L. S. Potter

(CHAPTER 9)

Figure 1—6 Volt Radio Battery

LAST month we discussed storage batteries from many angles. It was impossible, however, in the space available, to cover all the points. Such matters as putting batteries into service—repairs, were left untouched, and these we will deal with before continuing further.

What must be done by the operator on receipt of a new battery from the makers? This will depend upon the condition in which it is received. A few batteries are sent out containing electrolyte, but not many. The majority are sent empty, and these may be dispatched in either of two ways, "dry-charged," or "unfilled." A tag attached to each battery will indicate its respective condition.

A dry-charged battery is one that has been assembled with dry separators and plates, without electrolyte ever having been added, but with the plates in a charged condition. A battery received in this condition may be stored in any clean, dry place provided the temperature does not exceed 110 degrees Fahrenheit, and will require no further attention during the first twelve months. The vent plugs and temporary seals for the holes must be kept tightly in position during this time. Figure 2 shows a cross section of a storage battery and will make clear the names of the various parts.

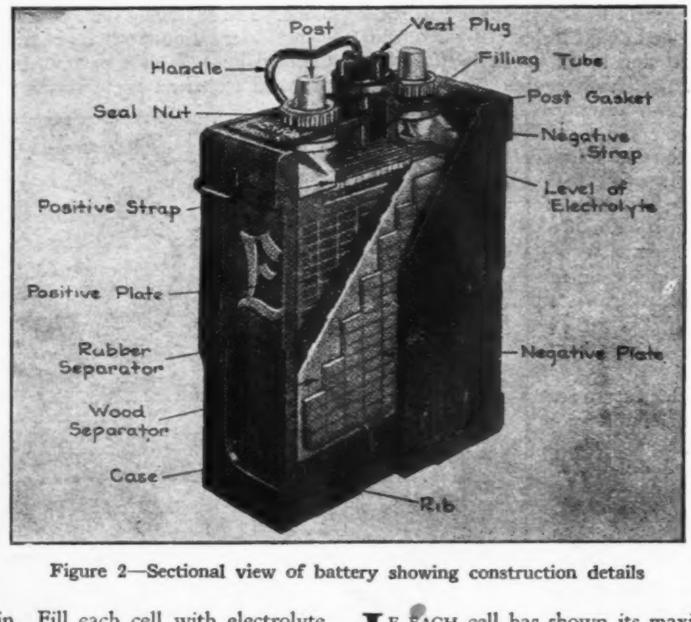


Figure 2—Sectional view of battery showing construction details

When the battery is required for service, remove the temporary seals and discard them. They must never be used again. Fill each cell with electrolyte, allow them to stand for an hour and then add sufficient electrolyte to restore to the proper level. The required specific gravity of the electrolyte and the level of the battery to which it should be filled, will be given in the instructions that accompany the battery. Vent plugs must now be replaced (make sure the vent holes are open), and the battery carefully wiped. It is then ready for service though better results will be obtained if it is given a six to eight hour charge first.

An unfilled battery is one that has been assembled with damp treated separators, without electrolyte having been added, and with plates that require an initial charge. A storage battery received in this condition requires about five days to put into service because the plates here have not been charged as in the case of a dry-charged battery.

The process of putting into service is precisely the same as with the dry-charged battery so far as filling with electrolyte is concerned, but it must be allowed to stand for at least twelve hours before more solution is added, and the level to which this must be filled and its specific gravity will be slightly different. Reference to the tag on the battery will supply this information and also the shop charging rate. The battery must then be put on charge for eighty-four hours at half the shop rate. Vent plugs must be removed from time to time to see that the electrolyte is being kept at its proper level. If necessary, more should be added. It is most important that the charge is absolutely complete before the battery is put into service, its future serviceability will depend on this.

How to Know When a Battery is Completely Charged

IF EACH cell has shown its maximum during the last ten hours of charging, it may safely be considered to be fully charged. If, at the completion of the charging period the specific gravity remains still too low, the solution should be drained from the battery and fresh electrolyte added and allowed to stand for ten minutes. Another hour's charge should then be given to mix the solution

thoroughly, and then a further reading taken. If necessary the charge must be continued.

Readings of specific gravity are taken with a hydrometer as explained last month.

If the battery has been allowed to stand beyond the time limit as shown on the tag, it will be necessary, before commencing the operations just detailed, to open up each cell to make sure the separators are not cracked, warped or split.

How is a Battery Opened Up?

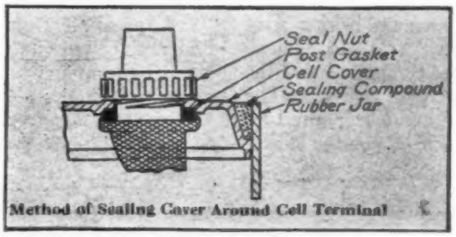
THIS is an operation which is generally best left with a reliable service station, but it may fall to the lot of a radio operator, and a knowledge of the steps necessary should form a part of his stock in trade. His ability to take complete charge of his batteries will certainly be an additional asset to his employers.

The following are the steps, given in their proper order, necessary in taking a battery apart:

1. Remove cell connectors.
2. Unseal cells.
3. Remove elements.
4. Remove covers.
5. Take elements apart.

Figure 3 shows two types of cell connectors, which with most batteries may be removed by holding a flame to the joints and pulling the connectors loose with a pair of pliers. Connectors will generally be damaged in this way and fresh ones will be necessary in reassembling the battery.

Unsealing cells. The plates of a cell, usually called the element, are secured to the cell cover by a seal nut and inserted in the jar. The top of the cell cover is then held firmly in position by the use of a sealing compound as shown in Figure 4. Some types of cells have a double flange cover as shown in Figure 5. In the first case, by heating a putty knife and running it round the outside of the sealing compound, this will be removed without difficulty. With the double-flange the same purpose is accomplished by passing a moderate flame round the underneath of the flange until this has been warmed sufficiently to loosen the compound. Probably an easier method in either case is to place the whole jar in hot water and wait for the compound to loosen.



Method of Sealing Cover Around Cell Terminal

Figure 4

The element, see Figure 6, is removed by holding the two posts with gas pliers and pulling. It may be a good plan to leave the jar in hot water as this causes it to expand and prevents the elements from sticking. See that any solution in the elements drains back into the jar before removing them completely.

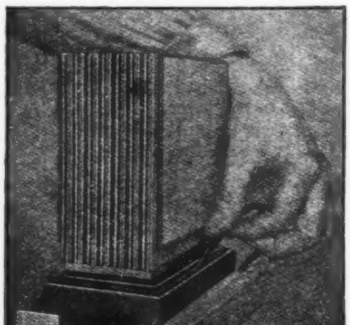


Figure 5—Applying sealing compound to double flanges cover.

It is necessary with aircraft batteries to remove the cover in order to assure correct reassembly, though in batteries of other types this may not be needed as the plates can be examined roughly without being taken apart and are more easily assembled. To remove the cover, the seal nut (Figures 2 and 4), must be unscrewed with a proper wrench. The makers of Exide batteries provide a seal nut wrench as shown in Figure 7. It is almost essential that the proper wrench is used because the thread on both the nut and the post is of lead and very easily damaged with rough handling.

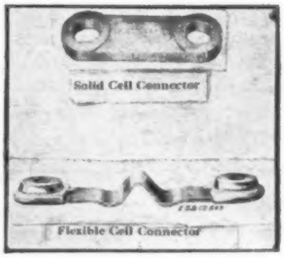


Figure 3—Cell Connectors

Taking Elements Apart

IT HAS already been mentioned that the plates and separators composing the elements of an aircraft battery are necessarily very thin for reasons of bulk and weight, and for this reason the life of an aircraft battery is generally shorter than those of other types. The elements of an aircraft battery can rarely be taken apart and assembled with any success. It will save both time and money if the entire element is renewed. With storage batteries of more rugged calibre the elements may be taken apart successfully. Lay them on edge, separate the plates slightly with a knife, and, commencing with the outside plates, remove the separators one at a time. The positive and negative groups can then be taken apart. If they are to be used again they should be kept completely immersed in water.

With a new cell that has been left beyond the maker's time limit, the element can be examined before the cover is removed. Any flaws in the separators will then generally be obvious, and unless they appear to be cracked or warped the element need not be taken apart. If the battery is one that has been abused—over-discharged for considerable periods, not correctly serviced, and the specific gravity of the different cells is not even up to within a range of fifty points after recharging, the trouble probably lies in the cells, assuming, of course, that the connections are good and the jars are not leaking.

Trouble will be found more often in the positive plates than elsewhere since the negative plates are less easily affected by abuse. An examination will show whether the active material of the plates has been washed out. The state of the plates will speedily reveal this. In this case, and also if any of the plates are badly buckled (warped), they must be replaced.

If the positive plates are buckled, the negative plates will be in a similar condition, and provided the buckling is only slight they may be straightened by placing them in a vise with boards of suitable thickness between each plate and outside the outer plates. Separators will always have to be replaced once the elements have been taken apart, and only the proper separators issued by the makers should be used. Commence inserting them from the bottom up between each positive and negative plate, starting with the middle of the group and seeing that the flat side

of the separator rests against the negative plate. The grooves should run vertically when the element is in the jar to allow a free passage for the electrolyte. When rubber separators are used, these must be inserted side by side with the wood separators so that the rubber is against the positive plate, and the flat side of the wood against the negative plate. Figure 9 shows a method of inserting separators.

Reassembly

In reassembling a cell it is always a good plan to stand both the covers and jars in hot water for a time. It makes them more pliable and easier to work in. The sealing of a cell is a simple matter. The cover must first be replaced, the sealing nut tightened, and the elements put back in the jar before the time is come for sealing. See that all traces of old compound are scraped off and the surfaces washed with a solution of common baking soda and water (proportions approximately 1:8), to remove traces of acid, and then wipe dry. The compound and the surfaces to be sealed must be heated slowly, and when the compound is thin enough to pour it should be poured on carefully. Providing it is not too thick or lumpy it will present an even surface when dry. The last step is to replace the connectors, and these being of lead must be burned on by melting the lead parts to be joined so that they become welded together. To do this the operator will need a carbon burning outfit. The method of burning is as follows:

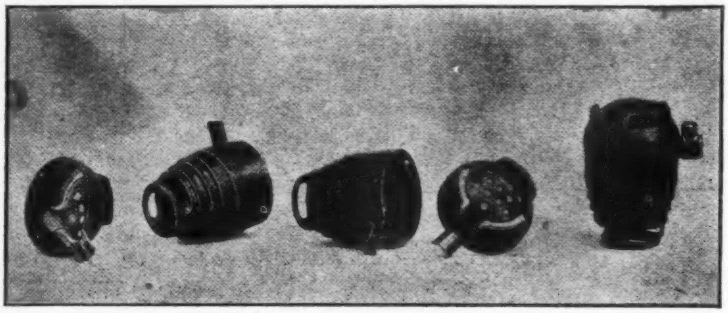


Figure 8—Copper housings for shielding of standard spark plugs

Connect a cable to a six volt battery, and by means of the clamp on the carbon burning outfit, connect the other end of the cable to the connector that is to be burned on. Next connect the cable of the carbon burning outfit to the other terminal of the battery. Holding the carbon rod to the joint to be welded will cause it rapidly to become white hot. The lead of the joint and the base of the connector will melt, and by moving the carbon rod continually round and puddling the lead, a fair welding can be made. It is sometimes necessary to use a lead strip to supply extra lead to fill the joint, but the operation remains the same. The carbon holder will need to be dipped in water from time to time to prevent it becoming too hot to hold, and also, after frequent use it may need to be scaled with a sharp knife to rid it of a film that often forms and prevents proper heating.

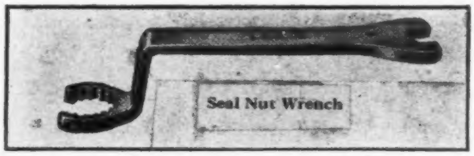


Figure 7

Storage Battery Hints

Do not bring any flame or naked light (this includes lighted cigarettes, cigars, etc.) near a battery without first opening vent plugs and blowing into the tubes to remove any gas, and then replacing vent plugs.

Do not use a metal spoon or container in mixing or filling electrolyte. Use glass or porcelain. When mixing, pour acid into water, not water into acid.

Keep the top of the battery clean. Smear joints only with pure vaseline. Wipe clean with solution of baking soda and water before smearing.

Do not allow cells to gas when charging. Reduce charging rate when this commences. See that proper connections have been made.

Maintain solution always at its proper level. Use only approved water for this.

Do not try to charge with alternating current.

If plates have been taken apart and are to be used again, see that they are kept completely immersed and not allowed to touch.

Figure 6—Element

Aircraft Radio

While radio for aircraft purposes does not differ in principle from any other type of radio, it has several problems of its own which demand the special attention of the man who is to specialize in aerial radio. The chief among these is undoubtedly ignition interference. When you remember the care and forethought that is used in selecting a site for a radio station so that outside interference may be reduced to a minimum, and then consider the case of an airplane where a motor, a few feet distant, is sending out sparks from 18 to 72 spark plugs across a miniature antenna formed by the high and low tension systems, at a rate of several hundred sparks a minute, you will understand the importance of ignition interference in aerial radio. This has been further demonstrated with a receiving set which was installed in a plane in which no protection had been made for ignition interference. The reception range in this case was between 25 and 50 miles. The same set, installed in a plane in which proper shielding has been provided, had a range of 125 to 250 miles. Since continuous communication from air to ground along the recognized airways of this country today, demands a range of at least 125 miles, it becomes obvious that adequate shielding against all sources of ignition is essential if aerial radio is to be used to the best advantage. Partial shielding is of little or no use. Unless the work is done thoroughly there will be no marked improvement. The obvious place for this work to be done is in the factory, but in these days of reducing manufacturing costs to a minimum, there are few manufacturers who are assembling their planes with anything like adequate shielding.

How Can An Ignition System Be Shielded?

This question is best considered by dividing the shielding needed into two parts—that for the High Tension system, includ-

ing spark plugs, magnetos, boosters with their appropriate switches and wiring, and that for the low tension system including starter, battery, generator and the appropriate switches and wiring.

So far as the spark plugs are concerned, there are several today which are provided by the makers with proper shielding. Alternatively it is possible to buy small caps for fitting over each plug. Figure 8 shows shielding caps for standard types of spark plugs, and Figure 11 shows a high tension ignition shielding on a wasp engine.

From the plugs the high tension wires to the magnetos must be enclosed in metal sheaths which should be grounded about every twelve inches. Obviously there can be no hard and fast rule laid down for shielding installations; they will vary with every type of plane. The important points to consider are stoutness of construction, lightness of weight and accessibility. It is no use having shielding that is not easily removable for inspection or that easily becomes broken.

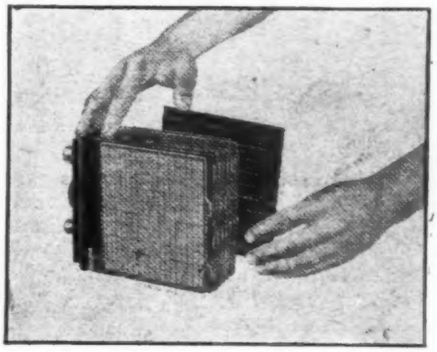


Figure 9—Inserting separators

Magnetos must be provided with a sheath fitting completely over the housing blocks, and particular care must be taken to completely shield all the wires from the magnetos to the pilot's switches and booster coil. A portion of these left uncovered may easily negative all the care given to the rest of the system. Well insulated, metal braided wire is easily obtainable, and if properly grounded will eliminate all ignition interference.

If the same precautions are taken with the low tension system, that is, all the wiring from the battery metal braided and grounded at frequent intervals, all terminals properly enclosed and no portion of the wiring left uncovered, the ignition shielding will be practically complete. I say "practically" because there may be such points as worn or dirty brushes in the generator, sparking perhaps all the time which will cause considerable interference. Brushes must be cleaned, and, if necessary, replaced. These are sources of trouble which the intelligent operator will track down down for himself.

In the future, perhaps, planes will be built with properly shielded ignition systems, but in the meantime it is not too difficult a task. An aluminum conduit for the wiring to pass through will generally give better results than metal braiding. It must fit snugly at the terminals and properly grounded.

Next month we will deal with radio installation in aircraft.

The author is indebted to The Electric Storage Battery Co. for permission to reproduce copies of illustrations relating to battery parts prepared by them, and to the Aircraft Radio Corporation for permission to reproduce Figures 8, 10 and 11.

If you like this "Course," write us.

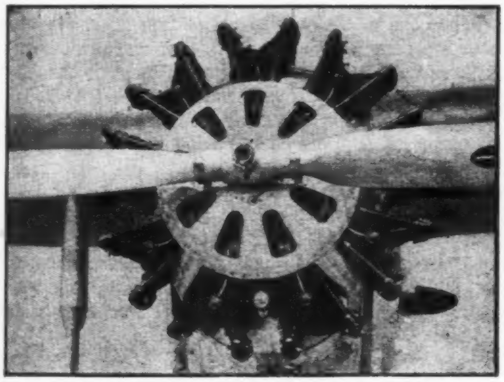


Figure 11—High Tension Ignition Shielding on a Wasp Engine

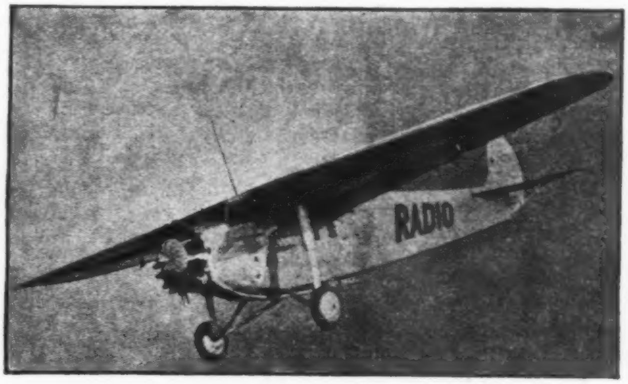


Figure 10—Radio Test plane No. 2. Fokker Super-Universal

A Balanced Wing Model

Something that is different—A remarkably stable plane that will provide a basis for many interesting experiments

By E. F. WALDRON

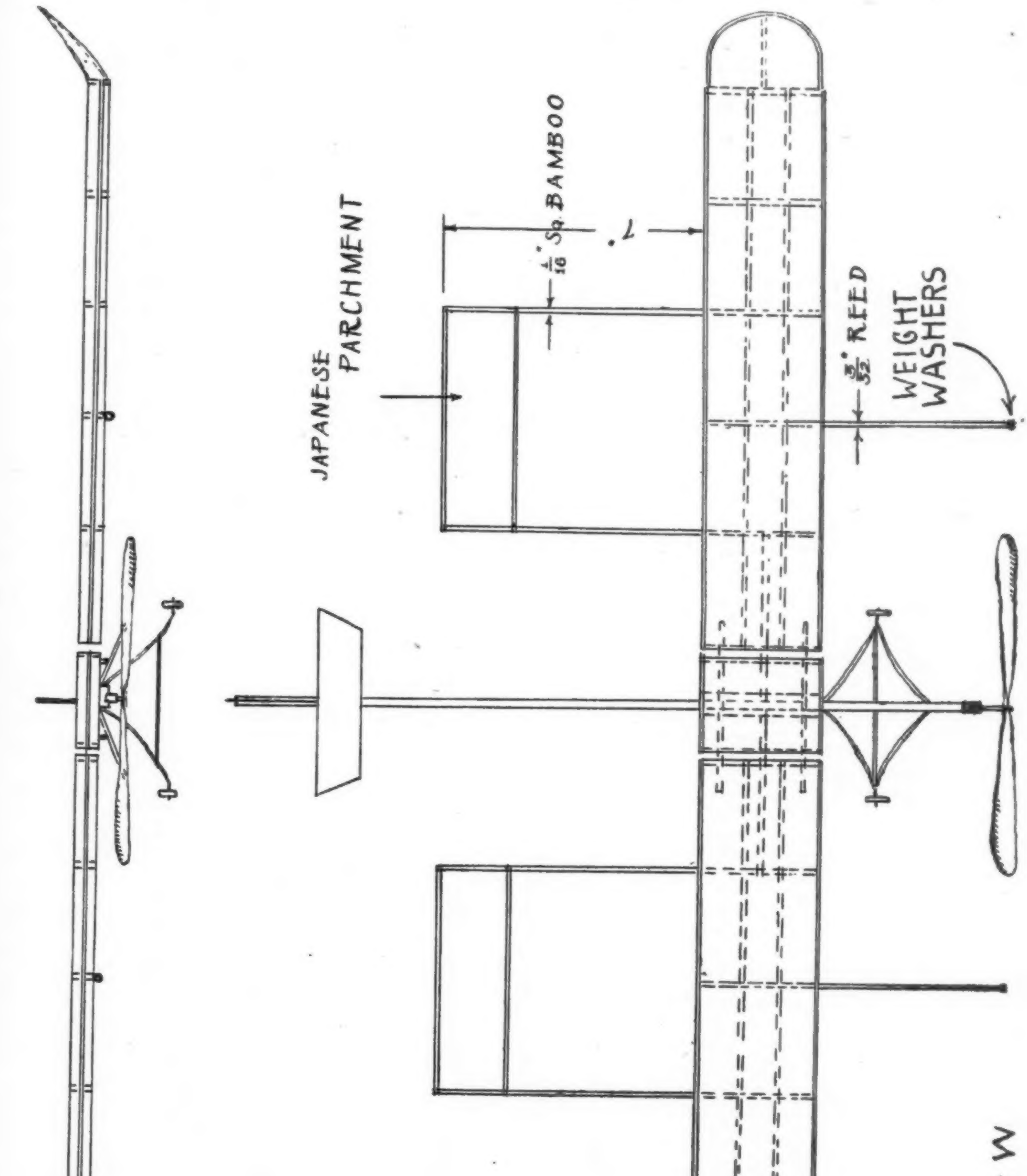
THIS type of model airplane will prove exceedingly interesting to make. We may call it The Balanced Wing Model. The idea involved is that, as a plane flies, the natural lift of the wing in a horizontal position maintains stable flight. However, as the plane slows down, the angle of the wing if changed is of direct assistance to prevent diving. This little plane when properly made and assembled will always land perfectly. It always flies level. The construction is simple, particularly for the experienced builder. The plane itself is not a fast flyer and is designed with a high lift wing, inasmuch as the purpose of the original design was experimental.

EACH wing is 15" long from the wing balance support except for the tips. These tips are 2½" long inclined at an angle of 45 degrees, and are made of 1/16" sq. bamboo. The leading edges of the wings are ⅛" by ¼". The trailing edges are 1/16" by 3/16". Inasmuch as it is a straight wing, the one cross-section of the wing shown gives the exact size for all ribs, of which there are 12. The automatic wing control is comprised of 2 ribs the same size as the others except that they are made ⅛" thick, and mounted on 2 (¼" x ½") balsa supports. These in turn are mounted on a motor stick support as per the diagram.

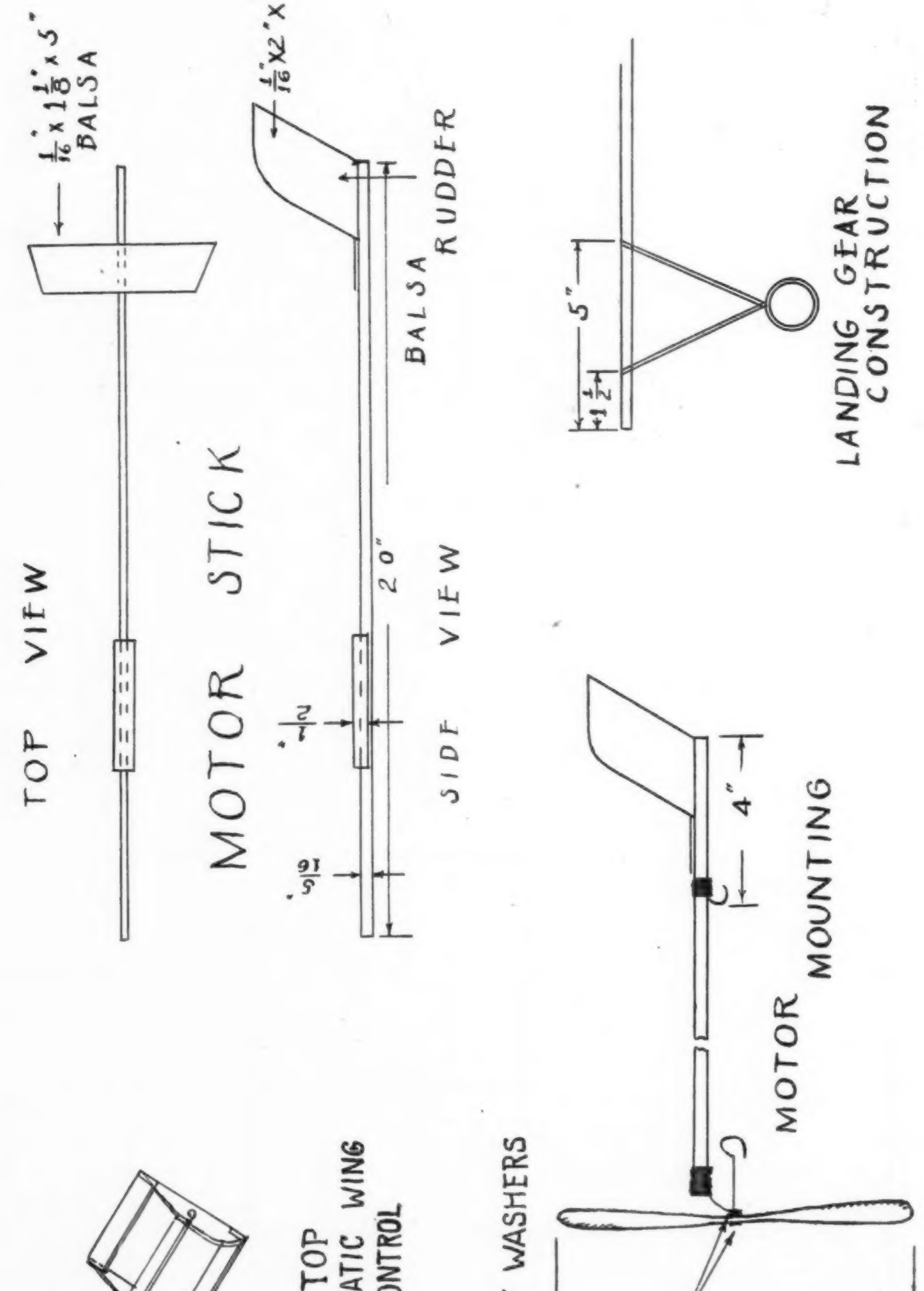
THE two wings are attached through the exact center of balance of the first two ribs through the wing support and thence to the other wing with a single (9" x ⅛") round wooden dowel. This must be carefully done so that there is absolutely no difference in angle between the two wings. After these are thoroughly glued and covered, attach the two tails to the wings. These tails will throw the wings off balance, and in order to re-establish the balance, a piece of 3/32" reed or 1/16" sq. bamboo is attached to the third rib of each wing leading forward. These lead forward beyond the wing approximately 6 inches. Small brass washers may then be added to the ends of these bamboo rods until a very nearly perfect balance of the wing is established. The wing must be just barely tail-heavy.

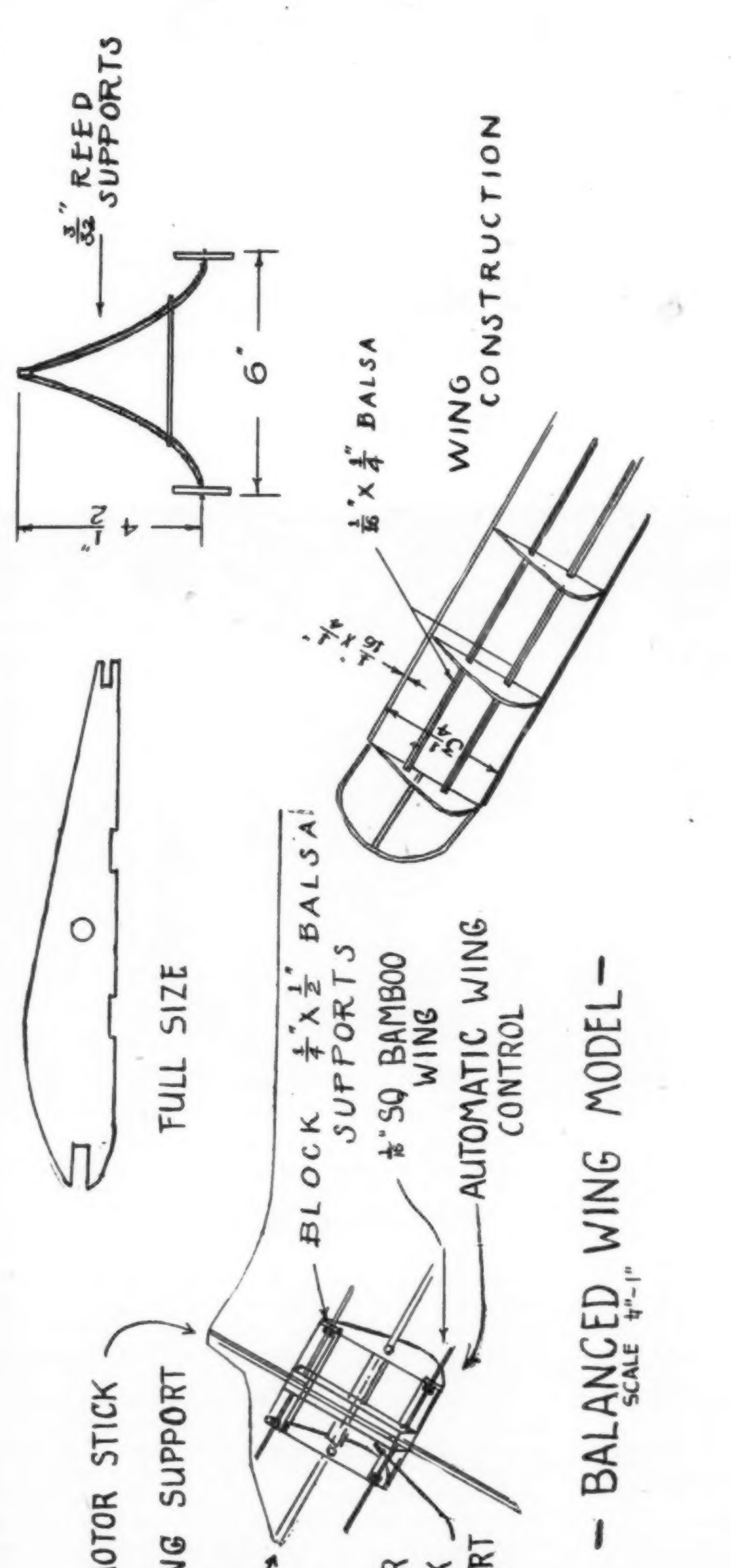
THE next step is to make the motor stick, the dimensions of which are given. This should preferably be of cedar. It may be built of balsa wood, but in that case it must be heavier. One "can" in the middle will allow one to maintain a fairly light stick. It must, however, be strong enough to carry twelve strands of ⅛" elastic. To this motor stick glue the tail and separate elevator. These should be made of 1/32" balsa wood. The landing gear is made of 3/32" round reed tied together with thread to the motor stick. The wheels are preferably balsa wood or celluloid. The propeller which is 9" in diameter, is of relatively shallow pitch. It may be made from a (1¼" x ¾") piece of balsa wood. When the motor stick, tail, landing gear, propeller, and motor are completely assembled, you are now ready to mount the wing. This is the most critical part of the whole task. You must find the exact center of balance of this assembly, and over this point glue the wing assembly so that the center of support of the wing and center of balance of the motor stick assembly coincide. When dry, glue on the wing motion stops; these are simply pieces of 1/16" sq. bamboo attached to the center wing support as shown in the diagram in dotted lines. The stops are so attached that when the plane is resting on its wheels, the wing tails will not quite touch the table surface. The front stop allows the same forward tilt as the back stop allows back tilt.

YOU will enjoy the many flights that this sturdy little plane will make. It will take off and land. It always lands right. It may be hand-launched at almost any angle, and will straighten up into level flight.


JAPANESE PARCHMENT
1/16" SQ. BAMBOO
7"
3/32" REED
WEIGHT WASHERS
TOP VIEW

N. B.


TOP VIEW
1/16" x 1 1/8" x 5"
BALSA
MOTOR STICK
SIDE VIEW
1/16" x 2" x 3"
BALSA
RUDDER
20"
1/2"
1/16"
5"
1 1/2"
LANDING GEAR
CONSTRUCTION
MOTOR
MOUNTING
4"
FLAT WASHERS
9"
TOP
AUTOMATIC WING
CONTROL



Airplane Engines

(*Continued from page* 13)

Secondly, the propeller is not splined directly to the crankshaft. It rides idly on the hub and is driven by a driving arm placed in the rear of the propeller. This arm is keyed to the shaft and is secured to the blades by rings and interposed between the blades and the driving arm are rubber blocks.

Thus, as the maximum piston pressure is applied to the propeller the rubber blocks absorb the initial shock before the crankshaft delivers its load to the propeller. These two devices make this engine as smooth as the normal radial Otto type powerplant.

The complete economy of the Diesel engine needs little comment. We all remember the single-flight endurance record set up by Lees and Brossy at Jacksonville. They landed their plane after over eighty-four hours in the air and then had fuel for another three hours.

Although the fuel oil used by this engine weighs slightly more per gallon than gasoline, the economy of operation is such that with an equal load the Diesel-engined plane has a twenty-five per cent greater range and will travel this distance for one-fifth the cost.

It is well known that the one hazard of the airplane that has not been overcome to any degree is that of fire in the air. Gasoline is probably the most dangerous of fuels. One gallon of gasoline has a heat value equivalent to ninety-six pounds of dynamite.

Even though the fire should be comparatively remote from the pilot, it might destroy the controls and cause the plane to crash. As long as open exhaust-flames and hot engines are in the proximity of the volatile fumes of gasoline this danger will exist.

The Diesel engine offers the best solution to this problem. The hydro-carbons used as a fuel will not burn except under a high degree of atomization and heat. As a matter of fact this fuel will actually extinguish a fire if poured on it. As if in tribute to his inventive genius the Diesel-powered plane which carried Captain Woolson to his death in a blinding snowstorm did not catch fire.

The elimination of the ignition and the carburetion systems have removed many sensitive parts from the normal powerplant. The carburetor in particular requires to be finely adjusted and any variation of the ideal setting will cause the pilot trouble. Further than that, cold, moist weather will often cause the carburetor to gather ice and become inoperative.

The ordinary engine must not be allowed to get cold when gliding the plane or else the sparkplugs will become fouled and the engine may not pick up, once the throttle is opened. Not so with the Diesel. The ignition is automatic and the heat of the cylinder is retained because of the compression every time the propeller turns the engine over. It will respond to the throttle at any instant.

If an airplane carries a radio set, much interference is set up in the receiving set every time the sparkplugs arc. The arc

(*Continued on page* 44)

AIR—WAYS

HERE and THERE

Get busy and "Air" your "Ways" of building and flying model planes. In each issue of Model Airplane News, space will be devoted to the activities of our readers.

Let OTHERS know what YOU are doing

FIRST of all, I wish to say "hello," to all of my old friends interested in Model Aeronautics, and to new friends as well.

This is Charlie Grant speaking over Station M.A.N.

Probably most of our readers do not know that Model Airplane News has honored me with the title of "Editor." Yes, it is true. Here I am, at your service, and asking for your cooperation in making "our" magazine a real representative of all model builders throughout the country. It cannot be done without your help. In order to have you feel that it is your magazine, we wish you to participate in making it worthwhile. Therefore you are going to have a chance to see your ideas in print; to tell others about your activities in the model airplane "Game."

If you would like to make this space more interesting to others, send in pictures of your models, with general specifications as to Wing Span, Wing Chord, "Prop," Tail, etc., or any story of your model-flying experiences that you think might be interesting reading. These should be short. It will be possible, then, to have a number of our readers represented in each issue. If your story should be too long, we will be unable to publish many other interesting news items. Don't hesitate, tell us your story now, and help us to help you to help others.

At your service always,
CHARLES H. GRANT,
(Editor.)

A GROUP OF PRIZE WINNERS FROM MISSOURI

Though some of these young men are from St. Louis, Mo., they do not "have to be shown" how to build Model planes. They showed others a "trick or two" at the Mississippi Valley contest, sponsored by Stix, Baer and Fuller Dry Goods Company, of St. Louis, Mo.

The Mississippi Valley Model Plane Contest

Some interesting information about the Mississippi Valley Model Airplane Contest has been sent in by Mr. Thomas W. Parry, Jr., of 511 Locust St., St. Louis, Mo. Here "tis":—Walter Westerfield, Jr., age 17, 1500 North Thirty-sixth Street, East St. Louis, Ill., took the grand award in the first annual Mississippi Valley model airplane contest at Parks Airport November 1, with an average duration of flight of 2 minutes and 15 seconds. His model plane was entered in three events. His model glider flight of 3 minutes and 43 seconds is believed to have established a national record.

Originally scheduled as a one-day event, the contest started October 31 and did not end until late the next evening. There was a total of 1000 flights. The contest, sponsored by the Stix, Baer & Fuller Model Airplane Club, attracted 110 entrants from St. Louis and surrounding cities. In addition to the trophy awarded by the club, Westerfield won an airplane trip to Oklahoma City and return. More than twenty cups were awarded.

Other winners were: glider contest, Junior division—Donald Lueke, first; Alphonso Wellhausen, second; Russell Hofmeister, third, and Herman Plegge, fourth. Senior

Contestants and their Model Ships at the Mississippi Valley Model Airplane Contest, Parks Airport, St. Louis, Mo.

division—Walter Westerfield, Jr., first; Charles Herr, Jr., second; Neal Compton, third, and William Eichhorn, fourth.

Outdoor fuselage contest, Junior division—George E. Bounds, Jr., first; Russell Yungbluth, second; Alphonso Wellhausen, third, and Carl Sandvoss, fourth. Senior division—William Barrett, first; Ralph Kummer, second; Robert Shackelford, third, and Bruce Boucher, fourth.

Twin pusher contest, Junior division—Alphonso Wellhausen, first; Oliver Volk, second; Russell Yungbluth, third, and Carl Sandvoss, fourth. Senior division—William T. Pascoe, first; William Barrett, second; William Enner, third, and Carl Fries, fourth.

Amateur sweepstakes contest, Junior division—Russell Yungbluth, first; Alphonso Wellhausen, second; William Sprotte, third; Oliver Volk, fourth, and George E. Bounds, Jr., fifth. Senior division—Raymond Volk, first; Owen Heitmeyer, second; Pete Sturm, third; Oliver Volk, fourth, and George E. Bounds, Jr., fifth.

Bob Loper of 1400 Boswell Avenue, Topeka, Kansas, sends us the following interesting account of The Kansas State Model Aircraft Tournament: Bob Loper "On the Air"—

A CLOSE race for honors in all divisions marked the Kansas State Model Aircraft tournament, held by the Kansas Free Fair, at Topeka, from September 15 to 19. Edwin O'Donovan and Robert Loper, both of Topeka, tied for the Senior State championship. Each had eighteen points. Joe Butrum, of Holton, won the Junior championship with nineteen points.

The Senior Champions. Edward O'Donovan, (Left) Robert Loper

The contestants were competing for three grand prizes, two trips to the national A.M.L.A. contest at Dayton, Ohio, next spring, and a set of Compton's Pictured Encyclopedia. The trips were donated by Senator Arthur Capper to be awarded to the two highest ranking contestants, regardless of class ranking. O'Donovan and Loper were awarded the trips, and Butrum, as Junior champion, received the encyclopedia. In addition there were cash prizes, magazine subscriptions, and other prizes awarded to winning contestants.

Joe Butrum, Holton, Kansas, Junior Champion

The two outdoor events were marred by cold, windy weather, and the longest flight, four minutes, was made by Robert Loper's tractor model. However, the contestants showed improvement in the indoor events, four boys passing the five-minute mark, a good record for the low-ceilinged city auditorium. Edwin O'Donovan's tractor model set the high mark of six minutes and forty-five seconds.

Many beautiful models were entered in the fuselage events, and O'Donovan made the fine indoor fuselage time of three minutes and fifty seconds.

L. P. Dittemore, director of the contest, says:—"This was one of the best contests we have ever held, and I want to compliment the boys on their fine initiative and good sportsmanship in building and flying their models."

Results of the contest:

Indoor duration.			mins.	secs.
Juniors.	1.	Joe Butrum	5	47.8
	2.	Leonard Hollis	5	28.3
	3.	Bruce Yanson	3	13.7
	4.	Ward Hollis	3	8.5
	5.	George Loper	2	35.6
Seniors.	1.	Edwin O'Donovan	6	45.5
	2.	Robert Loper	5	45
	3.	Clifford Messenheimer	2	39.5

L. P. Dittemore, City Playground Director and director of the Kansas State Miniature Aircraft Contest Topeka, Kansas.

			mins.	secs.
Indoor fuselage duration.				
Juniors.	1.	Joe Butrum	1	55.5
	2.	George Cookingham	0	56.8
Seniors.	1.	Edwin O'Donovan	3	50.5
	2.	Robert Loper	2	10.4
Outdoor duration.				
Juniors.	1.	George Cookingham	2	57.8
	2.	Joe Butrum	2	15
	3.	Elva Jean Dittemore	1	48.8
	4.	Tom King	1	0.4
	5.	George Loper	0	45.2
Seniors.	1.	Robert Loper	4	00
	2.	Edwin O'Donovan	3	56.7
	3.	Robert Meier	1	26.6
	4.	Clifford Messenheimer	1	4.9
Outdoor fuselage duration.				
Juniors.	1.	Joe Butrum	0	36.4
	2.	Leonard Hollis	0	29.4
Seniors.	1.	Robert Loper	1	36.2
	2.	Edwin O'Donovan	1	28.7

Standings for Senior state title.
1. Robert Loper, 18 points.
   Edwin O'Donovan, 18 points.
2. Clifford Messenheimer, 5 points.
3. Robert Meier, 3 points.

Standings for Junior state title.
1. Joe Butrum, 19 points.
2. George Cookingham, 9 points.
3. Leonard Hollis, 8 points.

Boys from Holton, Kansas. Ward Hollis, (Left), Joe Butrum, Billy Whitty, Leonard Hollis and Harold Hollis

Standings for Senator Capper prize trips.
1. Edwin O'Donovan, 18 points.
2. Robert Loper, 17 points.
3. Joe Butrum, 12 points.
4. George Cookingham, 5 points.
5. Leonard Hollis, 4 points.

Well, from these fore-going accounts it looks as if the boys from the "West" were "steppin' out a bit." What has happened to the rest of you model builders? Come on out in the open where we can see what you are doing. Don't hide your genius; send in the pictures of that new ship you have built so that other boys may see how "good you are." Or if you have a story to tell of an unsual flight, or a contest, let us have it. All such data helps the science of aviation to grow, so "do your bit."

WHEN YOU SEND IN MATERIAL FOR US TO CONSIDER, BE SURE TO MENTION WHETHER OR NOT, YOU ARE AN AMERICAN SKY CADET.

The American Sky Cadets

$5.00 Prize Given for Best Picture

MOST of the members of the American Sky Cadets were very busy during the Christmas Holidays. At least, I assume this is true, for no news of their activities was sent in to publish under this column. But as the old saying goes, I suppose "no news is good news." However, we are hoping that you fellows will not have "writer's cramp" next month, and that you do not take a job as night watchman. It is difficult to take good photographs at night, and our next issue will not be complete without your contributions.

In order to make it interesting and worthwhile for you, Model Airplane News offers a prize of $5.00 for the best picture of a model plane built by an American Sky Cadet, enrolled previous to the publication of this "Issue." The picture will be judged on the following points:

1. Its likeness to a full size airplane.

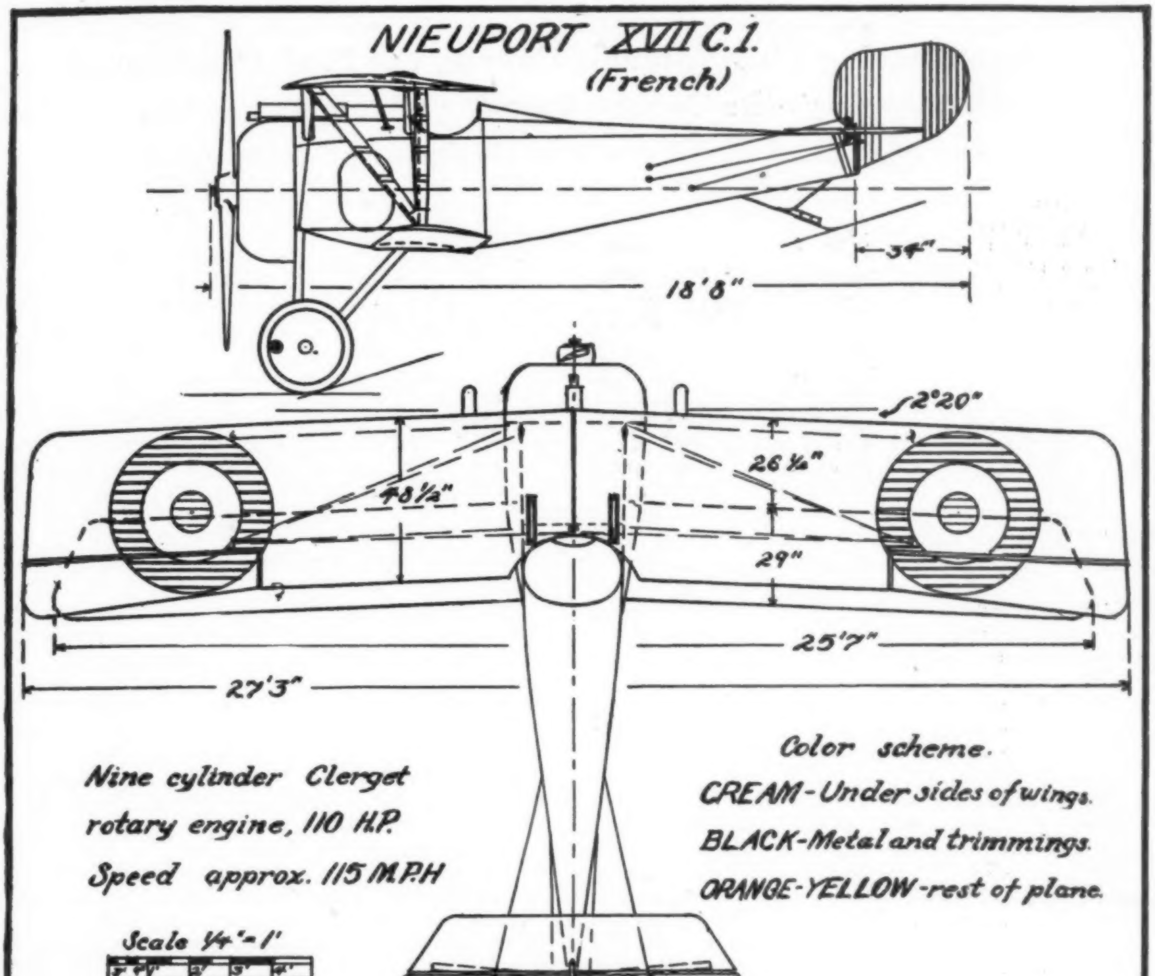
2. The quality of the picture in respect to photographic detail shown.

3. Photographs of planes in flight shall have precedence, the other two points being equal.

4. Two pictures may be submitted, one to show detail and likeness to full size planes, and one in flight to show flying quality. Such pictures will be considered as one entry and will have precedence provided no one else obtains equally fine results in one photograph, namely, photographic detail, and flying quality demonstrated.

5. In case of a "tie," a prize will be awarded to each tieing contestant.

All pictures, to be eligible for a prize award must be mailed *to this office before* MARCH 10TH, 1932.


NIEUPORT XVII C.1.
(French)
3'4"
18'8"
2°20"
26½"
48½"
29"
25'7"
27'3"
Nine cylinder Clerget
rotary engine, 110 H.P.
Speed approx. 115 M.P.H
Color scheme.
CREAM - Under sides of wings.
BLACK - Metal and trimmings.
ORANGE-YELLOW - rest of plane.
Scale ¼" = 1'
4'10"
5'3"
Stockton Ferris, Jr.

A Course in Airplane Designing

By Mastering This Valuable Course, the Model Builder of Today Lays the Cornerstone for His Career as the Aeronautical Engineer and Designer of Tomorrow

ARTICLE 27

By Ken Sinclair

IN THE last instalment of this course I told you that "Everything is in equilibrium." Let us determine the significance of this statement.

What, we say, is equilibrium? From the first part of the word, *equi-*, we see that it has something to do with equality. It has. Equilibrium is a balance between two equal forces. There may be more than two forces—any number, in fact—but for the present we will consider two only.

Now if we cut the string in Figure 1, what would happen? Well, if someone's toe were under the weight, the toe would be damaged because the weight would drop.

Why? Newton reasoned that out, and decided that, since the five-pound weight—or any other weight—drops when the string is cut, there must be a force in the string before it is cut which is equal and opposite to the weight of the object.

That is equilibrium. The weight pulls down, or rather is pulled by gravitation, with a force of five pounds. Therefore the string must exert an upward force of five pounds to hold the weight. If the weight is twice as heavy the force in the string must be ten pounds. If the weight is twenty pounds the string must supply that upward force to hold it—and if it cannot supply that force it will break.

Everything is in equilibrium. A book, resting on a table, pushes down on that table with, say, a force of one pound. Then the table must push up against the book with a force precisely equal and opposite to that weight. An airplane, weighing a ton, is flying through the air in level flight. The wings must, by means of the air action, supply an upward force of exactly one ton.

All engineering is based on that principle. Learn it. Get it clearly in mind now. It is always true, whether the body in question is rising or falling or sliding or moving along a curved line. At any instant any object, or any part of any object, is in equilibrium.

If I push on a wall with a force of ten pounds, the wall must push back against my hand with an equal and opposite force. If the wall is not strong enough to exert that force, it will collapse. If I have a wing-bracing strut, as shown in Figure 2, pushing against a fuselage longeron with a force of a hundred pounds, I know that the longeron must be capable of supplying a force of at least a hundred pounds in precisely the opposite direction.

Do you see how this works out for the engineer? If I have a force acting on a structure I can tell instantly that the structure must be strong enough to supply an equal force which acts opposite to the force applied.

Now someone might say, "You're crazy. If everything is in equilibrium at all times, how can we move a car or a book or a watch? How can we start a train?"

A question like that is a good sign because it shows the person is using his head and thinking for himself. I'll try to show just why everything is in equilibrium at all times, even if it happens to be moving; but that introduces something else that we must talk over first—Motion.

What is motion? We might say that it is the process of getting from one place to another. At any rate, we all know just what motion is. Now we must have a way of handling motion and representing it on our drawings so that we may work with it.

If a plane is taxiing at such a speed that it covers ten feet in one second without changing speed, we say that it is moving at the rate of ten feet per second. That is our rate of motion. We can indicate that velocity by an arrow on paper, making the length of the arrow represent, to any convenient scale (provided we stick to that same scale all through our drawing) a velocity of ten feet per second. The head of the arrow will indicate the direction of motion. If we used a scale of ten feet per second equal to one inch, then, the arrow would be one inch long. That is how we indicate motion.

The same thing works for forces. Here again we choose a suitable scale, being careful to keep our lines on the paper exactly in the directions of action of the various forces; and the arrow heads indicate the direction in which the forces are acting. To indicate a force of five hundred pounds, using a scale of one hundred pounds to the inch, we would use an arrow five inches long, pointing in the proper direction.

So much for the indication of motion and force. Now let us get back to the matter of motion itself.

If an object moves at the rate of ten feet per second and covers ten feet in one second we know that its motion is *uniform*. That is, its velocity in a straight line does not change, being ten feet per second at the beginning of the second and precisely the same at the end of that time. There is no gain or loss of speed in uniform motion.

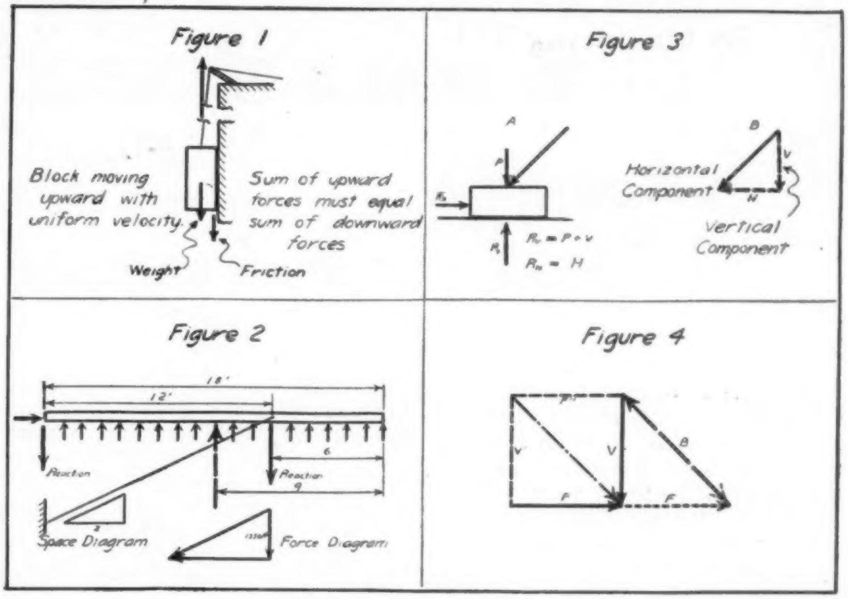
Now for equilibrium in uniform motion. Look at Figure 3. The block is being pushed along by the force at a rate of one foot per second. Where does our idea of equilibrium come in? We all know that when any object moves against another, friction objects. Friction bucks all motions, even that of a pendulum which suffers from air resistance. In the example shown, the block may be sliding on a board; there will therefore be friction between the block and the board. It takes a force to overcome this friction—and, *in uniform motion on the level, the pushing force must be exactly equal and opposite to the friction force.*

This is another case where equilibrium comes in handy to the engineer. Knowing the friction force, he can immediately decide just what pushing force is necessary to keep the block moving at a uniform rate of speed.

Why, if the friction force and the pushing force are

equal, doesn't the block come to rest? We'll answer that by asking another question. Why should it? We can't have friction without motion, and if the block should come to rest we would have no force opposing the pushing force. However, the block, as shown in motion, is in equilibrium. We accept that fact as obvious, since the two forces are now equal. To stop the block we will need another force to help the friction force work against the pushing force.

In the present state, then, there is no *reason* for the block to stop. Newton realized that, and stated another of his laws of motion: *Every body remains in its state of rest or of uniform motion in a straight line until a new force is brought to bear upon it to change that state.*



Theory and Application of Mechanics

Some sharp-witted reader now says; "All right. I can see how the block is in equilibrium while it moves at uniform speed, but you said that another force, added to the friction force, would stop the block. Well, that destroys the equilibrium. You've got more force on one end of the block than you have on the other."

That question brings in two very important matters: *Acceleration* and *inertia.*

We all know what acceleration is. If I push a book across a table, starting with the book moving at a speed of one foot per second and ending up one second later with a speed of five feet per second, we have an acceleration. The book has been accelerated from one foot per second to five feet per second, and its acceleration is therefore four feet per second, meaning that, in each second, it gains four feet per second speed. Acceleration, then, is *the rate of change of velocity*. It may be positive, if the body is speeding up, or negative (sometimes called deceleration) if the body is losing speed and slowing down.

However, by Newton's law a body will remain in its state of rest of uniform motion until acted on by some outside force; and, by the equilibrium law, all forces are balanced. For every action there is an equal and opposite reaction.

To accelerate the block shown in Figure 3, then, we must add a force, as shown. However, by the equilibrium law, our forces will still be equal.

Inertia steps in. Suppose I push open a heavy bank vault door. I'm in a hurry. I know that, when I push the door slowly, it resists only with a small force due to friction in its hinges. However, the door is very heavy, and as I try to speed it up rapidly—accelerate it, in other words—I am amazed at the force I must apply. Certainly the friction is no greater. What has happened?

Inertia force has opposed the rapid speeding-up of the door, and this inertia force, *which did not exist until actual acceleration took place, is equal and opposite to the force I apply beyond that used to overcome mere friction and air resistance.* That is a practical, everyday example which illustrates another of Newton's laws: *Any acceleration in the motion of a body is proportional to the accelerating force acting, and takes place along the line of action of that force.*

That is quite easy to understand. If I try to speed up that bank door very rapidly I find my task impossible. Why? The inertia is so great that I cannot exert an accelerating force proportional to the acceleration I wish to produce. The balance of forces holds, remember, because inertia comes from acceleration and acceleration from the accelerating force.

If I push with a force of twenty pounds greater than the friction force the door speeds up at a certain rate; and this speeding-up brings an inertia force of twenty pounds. If I exert forty pounds the door accelerates more rapidly, and this increase in acceleration brings an inertia force of forty pounds.

These last laws come in handy to the engineer, too. Their application in everyday work, though, is a little more complicated than that of the equilibrium law; and we will deal with them in detail later. For the present we'll stick to the application of one idea and remember that *everything, whether at rest or in motion, is always in equilibrium.*

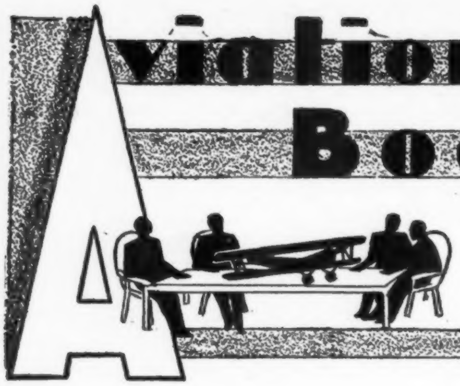
As we have said before, nearly every move in engineering design makes use of that fact. Get this "tool" at your finger-tips.

WE HAVE now got hold of some very valuable "tools" for use in airplane designing and other branches of engineering work. It was necessary in this and last month's article to cover quite a bit of ground; but now we're going to take those principles, one by one, and apply them to practical work, introducing a few new topics as we go along. By doing this we will find out just how valuable they are to the engineer and furthermore we'll get a much clearer idea of what they really mean when we start to use them.

The most important of them all, to us, is equilibrium. As we have just said, everything is in equilibrium. To every action there is an equal and opposite reaction. If a man can push on a wall with a force of fifty pounds the wall must resist with a force of fifty pounds directly in opposition to the applied force; if the wall is not strong enough to do that it will collapse before the man has been able to exert the full force of which he is capable.

That principle is fundamental (*Continued on page* 40)

Aviation Advisory Board



Conducted by
CHARLES HAMPSON GRANT
Formerly of
The Technical Section, Air Service, U. S. Army,
Chairman of the Board.

MANY of our readers, lately, have asked questions of a technical nature. There seems to be a great need for a simple explanation of basic rules for model design.

It is quite true that the young men in the model "Game" thoroughly understand the construction of planes, but the very basis of the whole art, (the understanding of the design or proportioning of the structure from an aerodynamic standpoint), has been lacking. So, hereafter, I shall devote most of the space of our advisory columns to answering basic technical questions on the aerodynamic design of the model. I therefore cordially invite you "to do your worst," and if you will forbear with me I shall try to answer you to your satisfaction.

One of my young readers has written to me requesting information about the design of the propeller. He tells me that he and his friends have more trouble with this one factor than with any other. It is true that it is the most difficult part of the plane to design correctly. Probably anyone can build a propeller, but to build a propeller that will properly operate with any particular machine requires an understanding of the technical design of the model. It is too involved a question to take up in detail here. However I can refer you to the articles which will appear each month in MODEL AIRPLANE NEWS on the aerodynamic design of the model. This series of articles will take up every problem that will probably arise. The first article appears in this issue. As the information requested about propellers will not be taken up for some time in these articles, I will sketch here a few brief points of importance for your immediate use. First, the diameter of your propeller should be approximately from 1/3 to 3/5 of the wing span. If the propeller were less in diameter it would be impossible to give its blades sufficient area to propel the machine properly. If it is more than 3/5ths in diameter the turning moment or torque of the propeller reacts against the machine so that it will have a tendency to turn over sideways. The longer the propeller the greater this tendency will be. This problem does not exist in the case of twin-propeller models, for where there are two propellers, either pushing or pulling the plane, each one turning in an opposite direction to the other. The torque of one propeller is then neutralized by the torque of the other.

One boy has written to me suggesting that it is necessary to know the weights of the machine in order to design your propeller. This is a misunderstanding. The problem of weight has nothing whatever to do with model propeller design. The relationship which determines the correct size for the propeller always exists between the propeller and the lifting surface. That is, in regard to the wing area, the lifting surface, the camber, the angle of incidence and the shape of the airfoil. For the details which will show this relationship very carefully and thoroughly I refer you to the series of articles

(*Continued on page* 48)

THE NEW CURTISS A-8 ATTACK PLANE
"Terror of the Skies"
This is one of an order of thirteen, built for the Army Air Corps. It is characterized as the most formidable air weapon ever devised for use against ground troops. It is said to have a speed of about 200 miles an hour and carries six machine guns as well as a bomb between the landing wheels. The claim is made that it is equal to the artillery and machine gun fire of a full infantry divison. What a ship!!!

The Automatic Pilot

Engineers Prepare for U. S. Test of Robot Air Pilot on Big Passenger Planes

By J. A. Fitz

ROBOT pilots may soon be flying passengers on big air transport liners from city to city if tests now being conducted by engineers of the Sperry Gyroscope Company, Brooklyn, receive the approval of officials of the Aeronautics Branch of the United States Department of Commerce, it was announced here today (Wednesday, October 7).

After successful experiments conducted by the army and navy air services for several years, the Sperry Company, manufacturer of the robot pilot, has now received permission to introduce the device to civil aviation and is engaged in a series of tests with one of the big 18-passenger Curtiss Condors such as are flown by Eastern Air Transport between Newark and Jacksonville. The plane will arrive at Newark Airport today (Wednesday) on a test flight from the plant of the B-J Aircraft Corporation at Baltimore, where installation of the pilot was made.

According to R. E. Gillmor, vice-president and general manager of the Sperry Company, the present tests are being conducted preliminary to official flights soon to be made for inspectors of the Department of Commerce. He said that as soon as the department has given its approval, the Sperry pilot will be made part of the regular safety equipment of Eastern Air Transport's planes.

The present installation of the pilot is the first ever made on a commercial airplane, it was said, the device having been developed by the Sperry engineers for use by the military forces of the nation in guiding heavy bombing planes on long night raids over enemy territory.

Although the engineers consider introduction of the Sperry pilot to civil aviation of great importance in the development of the nation's air industries, they attached greater significance to the military aspects of the civil adaptation. They pointed out that the practical everyday use of this and other new devices is invaluable to American military aviation because of the constant testing and proving of the instruments in all kinds of weather and under all flying conditions. It was pointed out that the Curtiss Condors on which the commercial tests are now being made are sister ships of the great Curtiss Condor bombers employed by the army and on which the Sperry pilots have been tested, and that, consequently, whatever practical knowledge results from every day use of the pilots by Eastern Air Transport is in effect valuable military information. In other words, they saw civil aviation, through its tests of such instruments, working hand in hand with the war and navy departments and adding to military aviation a great emergency reserve strength.

Mr. Gillmor said today it is not intended that the Sperry pilot shall entirely displace the human pilot in commercial aviation. He said the robot is to be installed only as an aid and auxiliary and that the installation is such that control of the plane can be given to the mechanical pilot or returned to the human aviator in a fraction of a second and without the slightest interruption of flight. A special point was made of the additional fact that the robot, by keeping the plane under control, frees the pilot so that he can devote himself to the important task of checking the course and analyzing weather reports.

The greatest value of the Sperry pilot, Mr. Gillmor and his engineers believe, lies in its unfailing precision and accuracy, and its ability, therefore, to fly an airplane with greater skill than a human pilot. The human pilot, at the outset of a trip, they explained, can make about 50 corrections per minute but as the flight continues over a long period, fatigue reduces his ability to as low as 20 corrections per minute. The robot, however, never tires. Similarly, flight is smoother with the mechanical man at the controls; when a wing dips with the human pilot the motion is already well under way before he can detect and correct it, but the robot, being gyroscopic, begins correction of the variation at the instant it begins.

With the installation now being tested, human hands, as a matter of fact, are required only on the take-off and landing, the engineers said. Once the plane is in the air the human pilot sets it on its (*Continued on page 45*)

The Sperry Automatic Pilot
"The Machine With a *Mind* Of Its Own"

Course in Airplane Design

(Continued from page 37)

to all engineering work. Now, to get a better understanding of it, we will apply it to a few practical, everyday cases.

We often apply the idea of equilibrium without realising, consciously, that we are doing so. If, for example, I have a barrel weighing one hundred pounds, which is to be lifted into a truck. I ask someone how much force I will have to exert to lift that weight vertically. He says, almost instantly, "A hundred pounds."

In that case we have a certain thing to be accomplished. We know that the lifting force must work against the attraction of the earth for a one hundred pound mass; hence, knowing that action and reaction are always equal and opposite, we say that a force of one hundred pounds must be exerted in a direction opposite to the pull of gravity.

But now suppose we are pulling a weight up the side of a building which is under construction, as shown in Figure 1. The wall is vertical, but it is necessary to have the weight touch on the wall because our derrick boom is not long enough to swing it free. We want to know what force we must exert to move the weight steadily upward.

Here we have *two* forces working against us. We have the weight of the body. We have also a friction force arising from the sliding contact between the weight and the wall of the building and opposing the direction of motion.

Friction will be discussed more in detail just a little later. For the present we'll say that it is, in this case, a force of one hundred pounds. The weight of the body, let us say, is one thousand pounds.

We have two forces working against one; but the equilibrium must be there all the same or else the weight will not move with uniform velocity. Therefore the *sum* of the upward forces must equal the *sum* of the downward forces, no matter how many of either there may be.

We have a total downward force of one thousand plus one hundred pounds, or eleven hundred pounds. Hence the upward force supplied by the rope or cable must be exactly eleven hundred pounds. If a man is hanging onto the block, his weight must be added in, and the tension in the rope increased by the amount of his weight.

All that may sound rather simple and elementary; but get it well in mind. If you grasp the true meaning of equilibrium you are off to a flying start. Remember that everything is balanced. If the applied forces are unbalanced—that is, if there is a thousand pounds total force acting in one direction and only five hundred acting in the opposite direction—there will be accelerated motion in the direction toward the weaker forces, with the amount of the acceleration such, that it supplies an inertia force large enough to balance things up.

Just above we were speaking of a square body with the force acting upward and downward. Now consider the wing spar shown in Figure 2. Here we have the vertical forces spread out along a horizontal distance. The lift forces are trying to push

(Continued on page 42)

Trans-Atlantic Planes

(*Continued from page 9*)

but has good air performance.

Two very important design factors are responsible for recent advances in speed and lift, as exemplified in recent designs. First, the high lift wing or Aerofoil section; second, the low weight per horsepower of the motor. These two developments are the very wings of progress, on which aviation has made such rapid strides. The timely development of the high lift wing has had the effect of giving more lifting pounds per square foot of wing area, thereby eliminating the necessity of using several wings, such as we find used on the early types.

In the early type of plane a square foot of wing surface was required to support only a five or six pound load, while in recent successes such as Lindbergh's Spirit of St. Louis, and the Pathfinder of Williams and Yancey, we find that the wing load was as high as eighteen pounds a square foot at the start of their trip, and diminishing from that maximum as the gasoline is consumed.

Effect of Low Weight Per Horse Power of the Motor

The continual advances in motor design, and the application of newly thought out principles, have done much to advance aviation. Each year brings out new records of dependability of power plants, and today engine failures are few and far between. Fifteen years of expensive motor development has seen a change from a 90 horsepower motor weighing 425 pounds, to a present day product weighing 375 pounds and developing 300 horsepower. Developments in new and light metals, as well as improved designs, have done much to bring this important end of the Aeronautical Industry abreast of the advances in other branches.

Frank Luke, Jr.

(*Continued from page 23*)

him, Luke had his reply ready. Interrupting the stinging words of his superior, he said calmly, "At any rate I got a Boche." The laughter which this statement brought from his more experienced comrades was silenced to shamed admiration when his confirmation arrived from an American Balloon observer.

Astounding as Luke's ability at downing enemy planes proved to be, this was not the branch of aerial combat which won him the lasting fame which is his today. Enemy balloons anchored to trucks and filled with inflammable gases were this Arizona airman's target. Few were the fliers who cared to tackle these defenseless-looking monsters of the air. To approach within a radius of 100 yards of German observation balloons was considered, even by such fliers as Rickenbacker, Lufberry, and Ball, almost certain death. What pilot was skillful enough even in those days of heroes to brave a blimp's massed defenses of anti-aircraft artillery, long range machine guns and bomb throwing cannons? What ace, even of the days of 1914-18 dared try to pass the hovering flight of German war birds which constantly guarded each of these precious "eyes of the artillery," the German observation balloons? The answer is Frank Luke, Jr.

On September 12th, 1918, Luke, cheated of his prey, namely three enemy airplanes, which he had lost sight of in the sun, turned toward the village Marieulles, behind the German lines. Almost before he saw the balloon which was anchored there, his plane was sighted by its enemy aircraft guns or "Archies." Rookie though he was, Luke knew what to do. Climbing to a height of 5,000 feet he threw his Spad into a power dive. At the rate of 160 miles an hour he hurtled himself straight at the balloon below. Swooping to within yards of the belching Archies below the blimp he sent burst of phosphorous bullets at its thick side. This taking no effect, he spiraled quickly, and looked down again to send a second burst. Again with no result. Before he could return for a third onslaught, Luke's machine guns jammed. While the winch crews on the anchoring trucks frantically pulled the machine to earth, Luke calmly withdrew. With shells, bombs and machine gun bullets whirring around him, he carefully put into condition one of his machine guns. With a turn and swoop he was back again, to find the balloon only a few feet from the ground. Wheels almost touching the balloon, he raked its entire length with incendiary bullets. His reward was a hot belch of blue flame and a smothering cloudy black smoke from the exploding balloon.

(*Continued on page 46*)

(*Continued from page* 40)

the spar upward. The two vertical reaction forces are such that they balance the lift forces and maintain equilibrium. This case, by the way, is a practical one. The spar shown is that of a monoplane wing. The numerous one hundred pound forces represent the lift, split up so that we can handle it conveniently. The large upward force in the center of the wing, shown by a dashed line, also represents the lift force, this time concentrated in the center for easier calculations. We can thus concentrate or divide forces whenever we find it handy, provided we keep their amounts and locations right.

The reaction at the right is the vertical force that must be supplied by the bracing-wire. That at the left is the vertical force supplied by the fuselage through the pin joint where the wing is attached to the upper longeron or to the center section. The horizontal reaction at the pin joint does not come from the applied forces, which are all vertical and can therefore have only vertical reactions: it comes from the fact that the actual force in the bracing wire is at an angle and therefore causes a horizontal compression in the spar.

Suppose, in this case, we knew that the vertical reaction at the left end of the spar was four hundred and fifty pounds. The lift force, being one hundred pounds per foot for eighteen feet of spar length, is eighteen hundred pounds. Then we have four hundred and fifty pounds acting downward against a force of one thousand eight hundred pounds acting upward. We will have to increase the sum of the downward forces by enough to make an even eighteen hundred pounds. The force necessary is found easily by subtracting four fifty from eighteen hundred, which gives us a vertical force of thirteen hundred fifty pounds as the vertical reaction supplied by the strut at its point of attachment to the spar.

That's simple enough, isn't it? And no one can say it isn't practical. Such a case pops up every day in a designing office. The general problem is to design a suitable strut for a wing of a certain size, having a certain lift force, without making the strut too weak or unduly heavy. Knowing the vertical force supplied by the strut—which we have just found—we can find the force in the strut parallel to its length and hence find what size of strut must be used.

We will do that in just a moment. But first we must point out that this business of equilibrium is true not only for vertical forces—it holds for all forces. The sum of the horizontal forces must equal zero, with forces acting to the right generally considered positive and forces acting to the left as negative. The sum of the vertical forces must equal zero. The sum of the forces acting in any plane must equal zero.

NOW suppose we look at Figure 3. Here we have a block acted upon by two forces, one vertical and one inclined at such an angle that it is neither horizontal nor vertical.

Looking back over the preceding paragraph, we see that the sum of the vertical forces must equal zero and that the sum of the horizontal forces must equal zero, if the block is to be in equilibrium.

But in the present case we're stumped because, while one force is vertical, the other falls into neither classification. What then?

That question brings us to a very important principle. *Composition and resolution of forces.*

Taking the inclined force from Figure 3 (A) and shutting it up by itself in Figure 3 (B), we scheme around and try to figure out a way to handle the ungainly thing.

Let's go back to our everyday experience. If I push down vertically on a block of wood, the block will not move, will it? It will merely push harder against the table or whatever it may be resting upon. But if I incline the force the block starts to move. What has happened? The force I apply is still the same. But its angle of inclination has been changed. It is the same force, but its total *effect* is no longer pushing down on the table. It now has some effect *horizontally*, although it is not yet a horizontal force itself. The more we cut down the angle between the force and the table the less becomes its vertical effect and the more becomes its horizontal effect.

We know that from experience. But just what have we been doing? We've been considering our force as really split up into two effects, one vertical and the other horizontal. As the inclination of the force becomes flatter and flatter, its horizontal effect becomes larger and larger, tending to push the block along with a greater force all the time until, when the force itself becomes horizontal, the whole effect is acting parallel to the table.

Now, going back to our inclined force in Figure 3, we can't change its angle of inclination. That is fixed. But we can determine what effects it will have vertically and horizontally and thus solve our problem.

We have been talking about these effects. Now we're going to call them *components*, one vertical and the other horizontal. Every force may be split up into two components, one vertical and the other horizontal, if necessary for simplicity and accuracy, by merely drawing lines vertically and horizontally from each end, making a triangle with one right angle as shown in Figure 3 (B). The force itself is still the same, acting at its previous angle; the components measure its effect in horizontal and vertical directions.

Notice that this brings us right back to our equilibrium of forces in vertical and horizontal planes. Hence we can, if we have a force inclined at a troublesome angle, split it up into components by drawing it to scale and making the triangle, and go right ahead.

Notice too, that the sum of the components, in themselves, is not the value of the original force. They are acting at different angles. If their effect is to be the same as that of the original force their sum must be larger than the original force.

THAT last may be a little hard to grasp. Look at it this way: If I want a stubborn mule to go forward I would push him forward, provided he were not of the kicking variety. But if he were too handy with his hoofs I'd stand at one side and push at an angle. Pushing in this way, however, I'd have to apply a much larger force than I would if I could push directly forward to get the same effect.

Given a force, then, we can always resolve it into components so that we can

handle things nicely on a drawing-board.

Above we found the values of the two components by drawing the force and the components to scale and reading the values of the components also to scale. But we have a right triangle, and if you've studied geometry you'll know that, in a right triangle, the sum of the squares of the two sides is equal to the square of the hypotenuse, or the longest side. Thus, knowing the value of any two sides of our triangle, we can find the third.

The block shown in Figure 3 (A), then, will have two components of the inclined force acting upon it, in addition to the vertical force shown. If the block is in equilibrium, which it must be, the table must supply an upward force equal to the original vertical force plus the vertical component of the inclined force. A horizontal force must also be present, either obtained from an outside source or from friction between the table and the block as the block moves to the left. This force must be equal to the horizontal component of the inclined force.

So much, then, for the matter of finding components of a given force. Now, reversing the process, we can find the effect of any number of forces. That is, we can find a single force that will have the same effect as any combination of given forces acting at any angles.

We will start with a simple case of two forces, F and V, shown in Figure 4. Both are acting on the point P, and the system is at rest. For simplicity, we'll just slide force F over so that it is in the position shown by the dashed line F. Now we have two forces, one horizontal and one vertical. We can consider these two as components of a single force, and draw in the line B, which is the single force having the same effect as V and F acting together, when the dotted head indicated its direction. We can, of course, slide this resultant back until its point will touch the point P, where it is really acting.

That method determines the resultant by using just the triangle of the forces given. We slid force F over because, when looking at the two given forces, we can see that the resultant (single force with same effect) will act at an angle downward to the right and not to the left. A better way of finding the resultant is by drawing the *parallelogram of forces*, F-V-F"-V'.

This is done by drawing F" parallel to F and V' parallel to V. These two lines intersect at a point O, and the resultant is the line drawn from O to P. The force found here is precisely the same as was found previously; but this method has the advantage that it can be used for two forces which are not at right angles to each other, while, in this last case, the geometrical methods of squares wouldn't work. The graphic method—usually the best and simplest—would, however.

Try this method. Draw several pairs of forces and find the resultants. It's good practice.

Now, suppose we have two forces and want to find a single force that will *balance* those two and establish equilibrium. This we will call the *balancing force*.

How shall we find it? That shouldn't be hard. We know that the resultant of a system of forces is a single force that has

(*Continued on page 45*)

Aerodynamic Design

(*Continued from page 6*)

surface of the double-surface wing is similar to the single-surface curve, but the lower is usually comparatively flat, as shown in the diagram.

Amount of Camber

Now that we know how our wing curve is to be shaped, we should know how high the curve or camber should be and how the height of the curve effects the flying qualities of our wing.

As a general rule, the higher the curve the more the lift at any given speed. Or, the higher the curve, the slower the plane is able to fly with any given weight. From this we can see that a comparatively low or flat curve will give speed to our model. In this case the greatest lift is produced at high speed.

The proper height of curve for a speed wing should be about 1/16 the chord of the wing. That is, if the chord is four inches, the curve should be about ¼ inch high at its highest point. For an average, every day model, the height of the wing curve should be about 1/12th the chord, i.e., ¼ inch high, if the chord is three inches. For a slow flying or endurance plane, the curve height may be ⅛ the chord or ½ inch high if the chord is four inches. In giving these figures, we are referring to *single-surface* wings. For double-surface wings, the height of the upper surface curve should be about 1/3rd greater.

In other words, if you have a single surface wing with a curve ⅜ inches high and you wish to make a double-surface wing with the same lifting capacity, at the same speed of travel, you would then make it with a top curve one-half inch high, instead of three-eighths inches.

The following formula shows approximately how the "lift" changes at any speed with the height of the wing curve. In the formula, L=Lift; C^u=(height of upper curve); C^B=(height of lower or bottom curve).

The values you get for (L) are not the actual amounts of lift but merely show proportion. We therefore put in (K) that represents a figure which we need not know, but which, if its value at any given speed were known, and this value were put into the formula, would give the actual value for the lift (L) in any case.

$$L=K\ (3\ C^u+C^B)$$

or in other words (L) is proportional to $(3C^u+C^B)$.

This applies to both single and double surface wings. If we had a wing of single surface whose curve height is 1/12th the chord, we would proceed as follows:

$L=K\ (3\ (1/12)\ +\ (1/12)=4/12=1/3\ K$

That is, the upper camber is 1/12 the chord and the lower camber is 1/12 as both cambers are the same in a single-surface wing. The height of the curve is always measured from the chord which passes through the leading and trailing (rear) edges of the wing.

Now, if we wish to design a double-surfaced wing with the same lifting capacity as the above single-surface one, we would proceed as follows:

$L=1/3\ K$ therefore $1/3\ K=K\ (3\ C^u+C^B)$

But in the double-surface wing we have chosen, the lower curve is straight with no camber, so (C^B) is equal to (O). So,

$$1/3\ K=K\ 3\ C^u, \text{ or } \frac{K1}{K9}=C^u \text{ or } C^u=1/9$$

Otherwise, the upper curve of our wing section should be (1/9) the chord if the lower camber is (O) or is flat.

To design a double-surface wing section with a flat lower surface that will have the same lifting capacity as a given single-surface one, multiply the camber of the single surface section by 4/3, as, 1/12 x 4/3=1/9.

You have probably noticed that the camber of the upper surface is multiplied by (3). The reason for this lies in the fact that the upper curve causes three times the amount of lift as the lower curve or surface.

The Airplane Engine

(*Continued from page 31*)

is a miniature spark transmitting set, the waves of which intercept the receiving antenna.

This interference may be such that radio telephones may not be used successfully. Since the Diesel has no ignition system, there can be no interference. Consequently, it is an ideal powerplant from a communication point of view.

This engine operates in any position as it does not depend upon gravity to obtain its fuel as does the carburetor equipped engine. Because of the greater expansion ratio the gases of combustion have a lower pressure when they are exhausted. As a result the exhaust gases do not expand so violently and the waves do not make such an impression on one's ears. Thus, the engine operates more quietly.

Because of the complete combustion within the cylinder the exhaust gases are not flaming as are those leaving the gasoline powerplant. The Diesel engine therefore makes an ideal engine for night flying as there are no flames to interfere with the pilot's vision. The exhaust stacks of the gasoline engine require special shapes and manifolds in order not to blind the operator. This adds weight and constructional difficulties.

The heavy oil used for Diesel engine fuel does not detonate. Consequently, the maximum pressure of approximately 1200 pounds which the Diesel engine is built to withstand can not be exceeded. Opposed to this is the gasoline engine which is constructed to withstand the normal pressures within the cylinder of around 600 pounds. Since detonation will build this pressure up to as high as 1500 pounds it is easily seen that serious damage to the engine will occur if detonation is permitted to continue.

THIS type of powerplant at present has two difficulties although these are not sufficient to restrict its use. The first is a low Mean Effective Pressure. Although a high peak pressure is built up within the cylinder this pressure falls off rapidly. The result is that the M. E. P. is lower than that of a corresponding sized gasoline engine. Consequently, the power is not so great for similar size.

The second point which will eventually be overcome is that of idling speed. It is rather difficult to control the fuel pumps so closely that the engine will turn over at a desired minimum speed of about 250 revolutions. Thus, as a plane comes in for a landing the fast idling engine will keep

the craft in the air resulting in the need for a longer landing field than should be necessary.

The many advantages of the Diesel type engine outweigh the few disadvantages many times over. Because of its weight this engine does not offer much to the military services. However, its increased economy should make it a favorite with the transport operators. Its superior reliability will make it practical to operate single engined passenger ships with complete safety. The elimination of the multiple engines on a plane will remove much resistance and increase the speed of our aerial transportation.

The succeeding article will tell some of the points to be observed during overhaul of an engine. It will discuss the importance of carefully running in and mounting an engine and how the life of an airplane powerplant can be prolonged by sensible operation.

Sperry Automatic Pilot

(*Continued from page* 39)

proper course and throws a switch which places the Sperry pilot in operation, taking his hands from the regular controls at the same time. If at any time the human pilot wishes to alter the position of the plane he has only to touch the proper buttons, to turn the plane to the left, to the right, up or down. It is significant that the plane loses no altitude in the turns.

The instrument not only maintains the plane in level flight but also keeps it on the desired course. The control is established by means of small gyroscopes, tiny models of the big rotors now used to steady some of the largest ocean liners, yachts, and foreign naval vessels. The gyroscopes serve to control a clutch relay which in turn operates the controls in much the same manner as the human pilot. The entire apparatus is inclosed in a small box under the pilot's seat. It weighs about 100 pounds.

According to its designers, the instrument will prove invaluable in rough weather and blind flying.

Course in Airplane Design

(*Continued from page* 43)

precisely the same effect as the original system. Then, using the law of equilibrium, we can *balance* any system by finding the resultant and then applying an *equal and opposite* force, which amounts to the same thing as taking the resultant and turning it end-for-end.

Figure 4 shows this. The resultant of forces F and V is force B, pointing in the direction of the dotted arrow. The balancing force is therefore the same force B, pointing in the opposite direction, as shown by the heavy arrow at the top.

Look at those arrowheads in the triangle at the right. Notice anything queer about them? They are all chasing each other around the triangle, like a squirrel chasing his tail around in a cage. That is a characteristic of systems of forces that are in equilibrium, or balanced. *If the triangle—or polygon—of forces is a closed figure, with the arrowheads chasing each other around that figure, the system is in equilibrium.*

Now for some more practical work.

Suppose we have a force acting vertically at the end of a strut, as that in Figure 2, and we wish to find the force needed parallel to that strut to supply the vertical force. We know that we have the vertical component and the angle of inclination of the force in the strut, since the force in the strut must be parallel to the strut and hence have the same slope.

We know the slope of the strut: it is 1:2, or one foot (or inch or centimeter) vertical to two similar units horizontally.

We draw what we call a *space diagram*, making it a right triangle with the vertical side one unit long and the horizontal side two units. Its hypotenuse is then parallel to the slope of the strut. Its vertical side is parallel to the vertical force that we already have.

Now we draw also a *force diagram*. We have only one line to draw definitely; the vertical force of four hundred and fifty pounds in this case, to scale. We draw that.

Now we know that, since the inclined force must be in the strut, it must be parallel to the strut. Therefore it must have the same slope as the strut or the hypotenuse of the space diagram; so we draw a line from the top of the vertical force parallel to the hypotenuse of the space diagram. We know that the force in the strut is represented by this line, but we do not know how long it is to be.

We do know, however, that the inclined force will have the same effect as a vertical component and a horizontal component. So we draw a horizontal line from the bottom of the vertical force until it strikes the inclined line. That point determines the length of the horizontal component and the inclined force.

We have found the inclined force graphically. We can also do it mathematically.

IN GEOMETRY, you have probably heard of similar triangles without having the faintest idea of what they were good for. Well, they come in handy right here. We know that, since their sides are parallel each to each, the space diagram and the force diagram are similar triangles.

Therefore, knowing the vertical force, we can set up a proportion:

1350:1 :: Inclined force:2.24

the last term being, in round numbers, the proportional length of the hypotenuse of the space diagram. (It is found by finding the square root of two squared plus one squared.)

The proportion is read like this, "Thirteen-fifty is to one as the inclined force is to two-point-two-four."

The product of the means of a proportion is always equal to the product of the extremes. That is, the outside terms, (1350 and 2.24) when multiplied together, will give the same number as the two inside terms, multiplied together. One of the inside terms is missing. To find it we multiply the outside terms together and divide

(*Continued on page* 47)

(*Continued from page 41*)

But, even in this moment of triumph, the jeering laughter of his comrades still rang in his ears. With the fusilage covering of his Spad flying in tatters and his wing fabric in shreds, Luke refused to turn his nose toward the home aerodrome. Sighting an American observation balloon he landed in the pasture lot below it, and obtained confirmation from its two observation officers. Confirmation in hand he climbed then into the cockpit of his shattered Spad and attempted to fly home. So badly damaged was the plane, however, that he could not take off, and reluctantly he was forced to return to his head-quarters by a lowly motorcycle.

So began the last two and one half weeks of life for this desert-bred American Eagle. Two days later Luke escaped from a flight of eight Fokkers to bring down a second German blimp. A third victory followed next day. But this time, Luke, aflame with the brave man's joy in defying death, not only brought down the balloon, but swooped within 100 feet of the belching Archies below and scattered their crew with his last seventy rounds of ammunition.

Yet this unheard of feat, must, in the light of Luke's later triumphs be counted only as "shadow boxing" for this greatest of all "Balloon Busters." On September 15th Luke brought down two well-protected German balloons in the morning, only to fly out again in the afternoon and get the third.

Morning patrol on Sept. 16th, and Luke searching the skies for his monster victims, found his prey grown wary. Upon the very approach of his fast flying Spad the blimps' crews invariably pulled down their charges, and Luke, daring as he was, found it impossible to penetrate the hail of shells, bombs and machine gun bullets which crowded the air above the balloons.

It was, therefore, with a new and daring plan that this Arizona miner approached his superior after luncheon that day. To his commander's amazement Luke asked permission to make a night raid, and stated that it would be possible for him to bring down at least three "drachens" in the period between the setting of the sun and complete darkness. That this feat would mean a return in the dark, his plane a target for American Archies as well as German, did not deter this most daring of all aviators. And daring alone Luke knew would not be enough. The landing speed of a Spad is 75 miles an hour, and landing even in daylight on a rough army field, was a feat many a pilot shrank from. Yet if Luke was to be successful in his night raid, a landing would be necessary on a darkened field without a guiding light of any kind.

But in the days of the St. Michel push, the knockout blow which was to crush the last defenses of the Fatherland, commanding officers were little concerned about the personal safety of their men. Yet because of Luke's value to the American Air Corps, he was given permission to make this unheard of attempt only if he would consent to the protective presence of a second plane, to be piloted by a Lt. Wehner.

Reluctantly accepting this proviso, Luke took off on the night of Sept. 16th, at 6:45 and turned toward Verdun. His comrades on the field knew where to watch, and at exactly 7:10 the first bloody flame appeared in the sky and they knew that Luke had carried out one third of his apparently unfulfillable promise. Eleven minutes later a second flame to the right of the first one lighted the skies momentarily and the watching war birds knew that Luke had produced this second installment of his deadly contract. Fifteen minutes later the third red emblem of death appeared against the black horizon. With hearts beating fast the First Pursuant Group waited now with straining ears for the hum of Luke's motors. Soon the faint drumming of the Spad's pistons reverberated above the field and Luke, his ship hit in several places by shells of the American Anti-Aircraft Artillery lighted as lightly and smoothly as a bird.

The efforts of Luke and the hundreds of thousands of other brave men on the days of Sept. 16th and 17th were not in vain, and the St. Michel's push was pronounced successful. Yet this Arizona cowboy did not feel that his work was done. On Sept. 18th, two more balloons were added to his record, one of which he accounted for at a distance of only 90 feet from the ground. As the hot belch of the burning blimp scorched his face, Luke glanced skyward to see a fellow pilot pursued by a formation of eight Fokkers. Stabbing at the belly of the lowest Boche, Luke sent him diving in flames toward the ground. With a turn he was on the tail of a second, and his tracer bullets sent that one too, hurtling to the earth. But Luke himself had not escaped unharmed. His plane was seriously hit, and pausing long enough to note that the plane which he had first come to protect was no longer in sight, he turned his nose toward the home field and left his pursuers far behind.

Upon returning to headquarters he found confirmations had arrived from general headquarters which pronounced him the chief ace of the Army Air forces. Yet this news was accompanied by information which took from him all its joy. He learned that the pilot friend whom he had risked his life to protect had fallen.

It is strange to think that this greatest of killers should be so deeply shaken by the death of a single man. Friendship being what it is, such however was the case, and Luke's superiors thought it best to send him on leave to Paris; that among the gay crowds he might forget, and return to his cruel but necessary work with a steadier nerve and a keener heart.

Such measures were soon found unavailing, for Luke was back at the front before his leave was over. On the very day of his return yet another friend flew into the skies and did not return. In his sorrow Luke forgot all discipline. Seeking solace in the clean air which he apparently could not find on the grave packed earth, Luke went on an unauthorized flight, during which he relieved his feelings by blowing up his eleventh balloon.

Upon being reprimanded and grounded by his superior Luke again took off. While he was in the air his commander telephoned instructions to the next flying field to place him under arrest, with the intention of bringing him back by motorcycle for immediate court martial. Yet to men such as Luke even Army rules are light bonds. Notified of his arrest, Luke walked silently to his plane, although darkness was already

(*Continued on page 47*)

Course in Airplane Design

(*Continued from page 45*)

by the present inside term, and get:
1350 x 2.24=3024 pounds, which is the force in the strut.
1

If you have not yet had experience with proportion and similar triangles, don't worry. Pick up a little as you go along by trying; and do a few examples of this sort graphically to get the idea of that method.

That's quite a bit for one article. Now we'll look at a few examples and try to get things straightened out a bit.

Example 1. A barrel is to be rolled up an incline. The slope of the incline is one in three. (One vertical in three horizontal.) The barrel weighs one hundred pounds. Neglecting friction, find the force necessary to push the barrel up the incline at uniform speed.

Solution: We will draw two triangles, one for space and one for forces. In the space triangle we know two sides. By squaring these, adding the squares, and extracting the square root we find the proportional hypotenuse to be 3.16. In our force triangle we know the hypotenuse, which is one hundred pounds. By similar triangles, then,

100:3.16::F:1

F=31.6 pounds. (100=31.6)
3.16

Example 2. In building an elevated hangar, it is necessary to determine the slope of the ramp up which the planes are to taxi. The type of plane used has an effective thrust, when on the ground, of one thousand pounds, parallel to the ramp and weighs ten thousand pounds. Find the greatest possible slope of the ramp.

Solution next month. Have it worked out and see if your answer checks.

The Clark Cabin Model

(*Continued from page 22*)

ailerons.

The wing is held onto the fuselage by means of two 1/8 flat rubber loops about 3½ inches long. (Not given in material list.) A loop is used on each side of the body. Each band is hooked around the two wing hooks on one side of the fuselage and then stretched with the fingers above the fuselage and the wing is slipped through the loop and across the top of the body.

Propeller

THE propeller is carved from a Langley type true-pitch blank, (5/8 x 1 x 7½.) "Coping saw" cuts, made in the block in to the "boss," will make it easier to cut the blank out. Carve the blades to about 1/8" thickness at the hub, tapering to 1/16" thickness at the tips. Drawing No. 6.

Drill a 1/32 hole for the propeller shaft. Round off the tips of the blades and sandpaper to a smooth finish with (OO) sandpaper, carefully balancing the propeller. Make the bearing plate as shown in Drawing No. 6 and cement to the back of the hub. This prevents the washers' wearing into the wood.

Give the propeller two coats of dope, sanding with (OO) paper between each coat and after the last one. Check again for balance.

Prepare the propeller shaft to plan and cut off the brass tubing bearing piece. Take the nose plug and run the shaft through from the back. Slip on the washers and tubing piece in the position shown. Fit on the propeller, and after carefully bending back the front end of the shaft, sink it back part way into the hub. Cut a piece of No. 10 music wire 1/4" long, and insert it under the bend in the shaft, across the front face of the hub, so that the shaft will straddle it. Now push the hook of the shaft all the way into the hub, tight against the 1/4" wire piece and apply a coat of cement. The shaft straddling the wire will be unable to rip through the soft balsa under the pull of the rubber. The propeller may be finished with a coat of silver dope.

The motive power is supplied by six strands of 1/8 flat rubber, which, if lubricated with glycerine, will stand about 600 turns given through a 5 to 1 winder. The rubber can be stretched out the back of the fuselage by means of the tail plug and winding hook.

The usual course is followed in making flying adjustments, namely, moving the wing ahead if the plane dives and moving it back if the ship stalls. Also some adjustment can be made by means of the rear propeller hanger as noted in the description of the fuselage construction.

The model takes off very nicely and with proper setting, it should fly about 500 feet.

Frank Luke, Jr.

(*Continued from page 46*)

approaching, and with a shout to the amazed officer took off; his comrades never saw him again, dead or alive.

Fifteen minutes after his Spad's wheels left the ground, Luke accounted for his first balloon. Turning in a westerly direction he sped to his second victim. On the way, a flight of German planes dove on him and Luke, from the blood spattering on his instrument board, must have realized that he had been wounded. Was there a pilot in France that day, who severely wounded, under arrest, and awaiting disgrace, would have continued his flight? Yes, there was one, Luke! Diving in a clever simulation of death, he escaped the Fokkers. His plane, now skimming the tree tops could not gain altitude. Reaching the balloon, he lunged from beneath, and with twin machine guns spitting fiery death Luke wreaked his vengeance on the monster drachen. Banking sharply he turned toward the town of Nuielly and with a single swoop accounted for his third balloon.

As he wheeled away from the scene of ruin he had produced, it must have come to him that his last victory had been won, for the gallant Spad beneath him could go but little further. It was for that reason, we believe, that Luke made no attempt to reach the friendly landing fields far behind his rudder. Soon his motor coughed for the last time, and his prop revolved no more. Going into a deceptively gentle glide, Luke floated over a small village, the streets of which were filled with German troops.

But if Luke's Air Broncho had lost its power, his guns had not. As he planed

(*Continued on page 48*)

Frank Luke, Jr.

(*Continued from page 47*)

slowly to the ground Luke's twin Luis guns spat death to six fleeing Germans. At last his wheels touched ground. Getting out of his cockpit he found himself surrounded by hundreds of gray clad enemies. Though generous cries of "Surrender" filled the air, evidently they did not reach this hero's ears. Without a word he drew his automatic from his holster and shot cooly at the mass until his ammunition was exhausted. For a moment, then, his hand rested as if in an affectionate caress on the fusilage of his tiny plane. Outlined in the dusk his frame made a perfect target. A dull crack from the woods before him was heard. Upright, he remained for a split second, then dead on his feet, Luke slumped slowly to the ground.

Glorious as was his death, no official word of it reached the A. E. F., till Jan. 3, 1919. When the full story of his last combat became known, from German war records, the Congress of the United States in full session, rated Frank Luke, Jr., the highest award in its power—the Congressional Medal. No other flier before or since has so been honored. That is fitting, no pilot, living or dead so deserved it, as this Arizona miner, America's Second Ace.

Advisory Board

(*Continued from page 38*)

which I have mentioned before.

After considering the diameter of our propeller and determining its correct value, the next problem to solve is the amount of pitch to give it. As a general rule to follow, the amount of pitch should be equal to 1½ times the diameter. That is, if the propeller is 8" in diameter, the pitch should be approximately 12". This is for the average model. For racing planes I would suggest that the pitch be equal to about 1.8 times the diameter. Many of my friends confuse the angle of the propeller blades with pitch. Always remember that the pitch of the propeller is the *distance* that the propeller will screw itself through the air in one complete revolution. This is called the actual pitch. In order to make a propeller with a pitch equal to 1½ times the diameter, the block from which the propeller is cut, should be twice as wide as its depth. For instance, if you wish to make a 10" propeller with a 15" pitch, the block from which we would cut it should be 10" long, ¾" deep by 1½" wide. It may also be 1" deep and 2" wide. The important point is that the width should be twice the depth.

Now we come to the most important phase of propeller designing, the significance of which very few boys understand. We might state as an axiom, that in any given machine the possible angle of climb will be proportional to the area of the propeller blades, the pitch and diameter remaining constant. In other words, the area of the propeller blades really governs the whole flight of the model. If we should have too little area the propeller would start to churn the air as soon as the ship began to climb up the air grade. (A good example of this is an automobile climbing a slippery hill. As soon as it becomes necessary for the car to exert great power the rear wheels slip, and cease to push the car along). That is just what happens with the propeller. The propeller should have enough area, so that when turning and pulling the machine through the air, the blades will pass through the air at an angle of about 4 degrees. At this angle they exert the greatest thrust for the least power applied. Too little blade area will cause the propeller blades to act at a greater angle of attack. For instance 8 degrees. At this angle, the blades are not efficient, and you are therefore wasting your power. Here is a simple rule which will always give you satisfactory results. The propeller blade area should be equal approximately to 1/10th the wing area of your model. Of course, the camber, the type of wing and certain other factors will make it necessary to vary the area at times, but this quantity of 10% will operate satisfactorily in about 99 cases out of 100. For instance, if we should have a wing on our model of 100 sq. inches, the area of the propeller blade should be 10 sq. inches, when the pitch is 1½ times the diameter. In order to be able to make a propeller of 10 sq. inches I will give you a formula which takes into account the length, depth and width of the block. The formula is as follows:

$$a = \frac{\sqrt{(d)^2 + (w)^2} + d}{2}\,(0.8)\,D$$

In the formula—(a) is equal to the area of two propeller blades.

(d) is equal to the depth of the block.
(w) is equal to the width of the block.
(D) is equal to the diameter of the propeller or length of the block.

From this formula you may determine the dimensions of the block that will give you a propeller of the proper area.

I hope my readers will take advantage of this new service which we are rendering to increase their knowledge of these very important principles of design. It will cut your work to about one quarter of what it is at the present time, in order to produce a successful model plane. By the cut and try method it is a long and tedious task. By this method, a flight may be obtained upon the first attempt every time—if you have been accurate.

MANY of our readers lately, have asked questions of a technical nature. There seems to be a great need for a simple explanation of basic rules for model design.

It is quite true that the young men in the Model "Game" thoroughly understand the construction of planes, but the very basis of the whole art, "the understanding of the design or proportioning of the structure from an aerodynamic standpoint," has been lacking.

So, hereafter I shall devote most of the space of our advisory columns to answering basic technical questions on the aerodynamic design of the model. We, therefore, cordially invite you "to do your worst," and if you will fore-bare with me, I shall try to answer you to your satisfaction.

e too
thura
climb
f this
hill,
e car
slip,
hat is
The
that
chine
ough
. At
t for
blade
act at
ace &
e not
your
will
The
prox-
your
pe of
ke it
, but
satis-
. For
n our
f the
when
in or-
of 10
which
and
is as

D

area

lock.
lock.
pro-

rmine
l give

ge of
ng to
y im-
l cut
hat it
oduce
t and
task.
tained
f you

asked
There
le ex-
design.
hen in
rstand
y basic
of the
ucture
s been

of the
wering
ynamic
e, co-
and if
try t

Attracting Friends with the WORLD'S LOWEST PRICES in MODEL AIRPLANE KITS and SUPPLIES

Eliminate guess-work, be safe and sure from the start by buying a Scientific Model Kit and using perfect parts to build your flying scale model.

EVERYTHING GUARANTEED!
3-HOUR SERVICE AS USUAL!

Headquarters of Scientific Model Airplane Co. at 277 Halsey St., Newark, N. J.

Model Airplanes *built with* SCIENTIFIC KITS *are* GUARANTEED TO FLY!

S.P.A.D.—Chaseiur—15" Wing Span **$1.25**

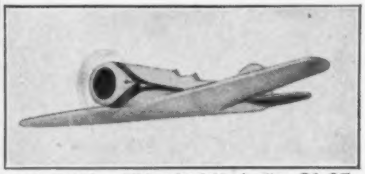
ALL SCIENTIFIC KITS come complete with full size plans, stamped ribs and bulkheads on balsa, hollowed balsa cowling, wire, banana oil, tissue, glues, all balsa strips and blocks, and everything needed to build these SCIENTIFIC Models. They are easy to build and will provide numerous thrills. These kits are by far the best model airplane values offered anywhere today because of their tested scientific design, flying performance, and low price.

Complete with Full Size Plans

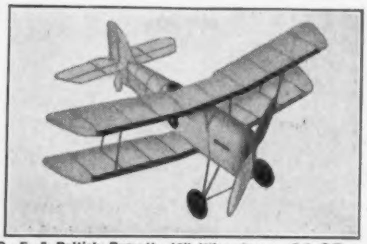
ALL ONE PRICE

1.25

Postage 10c Extra

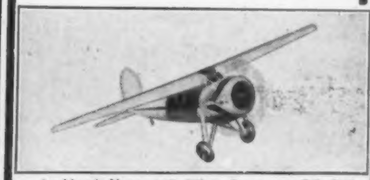


Lockheed Sirius—With retractable landing gear—15" Wing Span **$1.25**

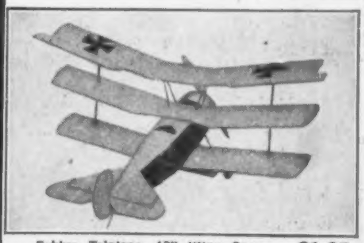


S. E. 5 British Pursuit—15" Wing Span **$1.25**

Scientific Model Airplane Kits have made an enviable reputation. Flying Scale Models built with these complete construction kits are instructive, educational and provide great pleasure. Enter a Scientific Model in the next local contest. They're winners.



Lockheed Vega—15" Wing Span **$1.25**



Fokker Triplane—15" Wing Span **$1.25**

Scientific Balsa Wood
36-inch Strips

1/16 x 1/16	$.01	6 for $.05
1/16 x 1/8	.01	6 for .05
1/16 x 3/16	.01	6 for .05
1/16 x 1/4	.01	6 for .05
1/16 x 1	.04	8 for .30
3/32 x 3/32	.02	6 for .10
3/32 x 1	.05	8 for .35
1/8 x 1/8	.01	6 for .05
1/8 x 1/4	.02	6 for .10
1/8 x 3/8	.02	6 for .10
3/16 x 1/4	.02	6 for .10
3/16 x 1	.06	6 for .33
1/4 x 1/4	.03	6 for .15
1/4 x 1	.07	3 for .20
1/2 x 1/2	.07	3 for .20
1 x 1	.18	3 for .50

Sheet Balsa
36-inch Lengths

1/32 x 2	.05
1/32 x 3	.10
1/16 x 2	.06
1/16 x 3	.10
1/8 x 2	.07
1/8 x 3	.12
1/4 x 2	.11
1/4 x 3	.19

Propeller Blocks

3/8 x 1/2 x 5	.01½
5/8 x 3/4 x 7½	.02
1/2 x 5/8 x 6	.02
1/2 x 3/4 x 5	.01½
5/8 x 1 x 8	2 for .05
3/4 x 1 1/8 x 10	.04
7/8 x 1 1/2 x 11	.06
1 x 1 3/8 x 12	.08

Plank Balsa
36-inch Lengths

1 x 1½	.31
1 x 2	.35
1 x 3	.40
1 x 6	.70
2 x 3	.70
2 x 6	1.10

Reinforced Heavy Duty Winders

Each	.35
Light Winders	.25

Aluminum Tubing

1/8 Outside Diam., Per Ft.	.07
3/16 Outside Diam., Per Ft.	.11
1/4 Outside Diam., Per Ft.	.13

Washers

⅛ Diam., Per Doz.	.01½
Per Gross	.15
¼ Diam., Per Doz.	.01½
Per Gross	.15

Bamboo

1/32 x 1/4 x 8	.00½
Per Doz.	.05
1/16 x 1/4 x 12	.01
Per Doz.	.08
1/16 x 1/4 x 15	.01
Per Doz.	.09
1/16 x 1/4 x 18	.01½
Per Doz.	.15

Shredded Bamboo

1/16 x 1/16 x 8, 2 doz.	.05
1/16 x 1/16 x 10, 1 doz.	.03
1/16 x 1/16 x 12, 1 doz.	.05

Japanese Tissue
For the Commercial Ship
Sheet 20½ x 24 .. .05

Scale Model Tissue
Sheet 21 x 25 ..2 for .05

Sheet Aluminum
12-inch Wide

.005, Per ft.	.13
.010, Per ft.	.20

Music Wire
Sizes .014, .020, .028, .034
15 Ft. for .... .05

Celluloid Wheels

¾ Diam., Pair	.07
1 Diam., Pair	.08
1⅜ Diam., Pair	.12
1⅞ Diam., Pair	.18
3 Diam., Pair	.35

Japanese Super Fine Tissue

Sheet 18 x 24	.08
Super-fine red tissue	.07

Thrust Bearings

Large Size .035	.02
Per Doz.	.20
Small Size .025	.02
Per Doz.	.20

Scientific Expert Rubber

.045 3 Ft. for	.01	225-ft. Skein	.70
1/16 Flat, 2 Ft.	.01	225-ft. Skein	1.00
3/32 Flat, 2 Ft.	.01	225-ft. Skein	.70
1/8 Flat, 3 Ft.	.01	225-ft. Skein	.70
3/16 Flat, 2 Ft.	.01	225-ft. Skein	1.00

Plans

Fokker Amphibian, Lockheed Vega, S. E. 5 British Pursuit Plane, Stinson City of Chicago, Rocket Plane, Capt. Hawks Mystery Ship No. 13, Fokker Triplane, Nieuport-Baby Scout, S. P. A. D.-Chaseiur, Albatross-DIII, Camel-English.

.10 Each ......3 for .25

A. M. L. A. Plans

.20 Each. Size 24 x 44-inch Vought Corsair; Fokker F-10; Stinson Lycoming; Waco Taper Wing; Lockheed Sirius, Boeing.

Add 5c when ordering plans separately.

Compressed Knockdown Motor Kit

1 Set Complete ... .90

Clear Dope

Large 2-oz. Can	.14
Per Pint	1.00

Colored Dope

2-oz. Can	.14
Per Pint	1.00

Acetone

Large 2-oz. Can	.12
Per Pint	.90

Ambroid

Large 2-oz. Can	.18
Per Pint	1.25

Colorless Cement

Large 2-oz. Can	.18
Per Pint	1.25

Banana Oil

Large 2-oz. Can	.12
Per Pint	.90

IMPORTANT!
Instructions How To Order

Orders cannot be filled unless you comply with instructions below:

1—Orders under 25c will not be accepted.
2—Add 15c for packing and postage on orders up to $1.50. Over $1.50 add 10 per cent.
3—Add 10c extra to above charges or orders west of the Mississippi.
4—Orders amounting to $4.00 and over are sent postpaid and insured except balsa planks.

Canadian Charges

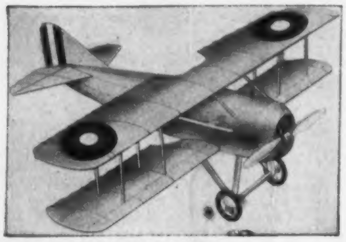
5—Add 25c for packing and postage on orders up to $1.50. Over $1.50 add 15 per cent.
6—Postage stamps. Canadian or Foreign Coin not accepted as payment.
7—Remit by check, postal or express money order. Make payment to Scientific Model Airplane Co., 277 Halsey Street, Newark, N. J.

Send 2c stamp for latest catalog containing world's lowest model airplane prices.

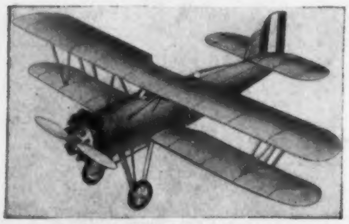
Scientific Model Airplane Co. 277 Halsey St. (DEPT. N-5) Newark, N.J.

Dealers and Clubs: ***Write for Special Price List***

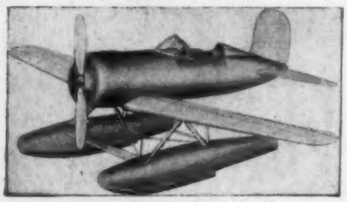
Here's Triple Value for One Price!



IDEAL SPAD
A wonderful reproduction of a French War-time Plane.



IDEAL VOUGHT CORSAIR
You'll be tickled with this Model of the popular Navy Plane.



IDEAL LOCKHEED SIRIUS
Every Builder wants this one! Lindbergh's Cross-Pacific Plane.

Kit No. 3 Contains

Complete parts, material, fittings, Plans and Instructions for Building the three Models shown above. All for $1.50.
(Postage 15c Extra)

Three Big, 15-in. Models of World-known Planes, all in One Construction Kit for

$1.50

BY MAIL, 15c EXTRA

LOOK at these actual photographs of these fine Models of world-famous planes — don't they look like the real thing? They are the neatest jobs you ever saw; perfect in every detail and with full-cabin fuselages and large enough to make building easy. You can fly them wonderfully, and they'll make dandy exhibition Models to show your workmanship.

Get busy and build them. It's easy, the IDEAL 3-in-1 Combination Kits contain everything required to build THREE Models: Balsa, Bamboo, Jap Tissue, Stamped Ribs, Fresh Rubber, Finished Wire Fittings, Propellers, Cement, Dope — everything, including Full Size Plans and Instructions for each Model. Biggest value we ever offered; if put up separately these Models would cost at least one dollar each. You save the cost of extra Kits.

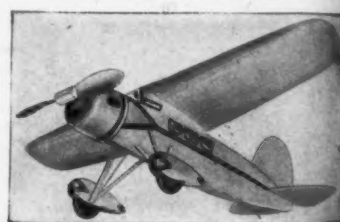
Three different Kits to select from—all three are illustrated here. Pick yours right away—remember, you get three Models for what one usually costs!

Order Yours Now!

Be sure to mention which Kit you want.

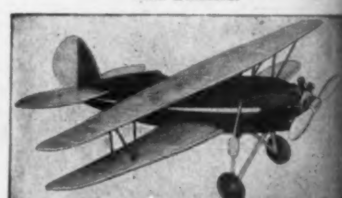
IDEAL AEROPLANE & SUPPLY CO., INC.
PLEASING MODEL BUILDERS SINCE 1911
20-24 West 19th St., New York City

Send Canadian Mail Order to
CANADIAN MODEL AIRCRAFT
47 Hawarden Ave. Montreal
(Canadian Prices are 40% Higher to cover Customs Duty)



IDEAL LOCKHEED VEGA
The Speed-demon Plane in a beautiful Model.

IDEAL FOKKER D-7
The German Biplane so popular with Builders.



IDEAL WACO TAPER-WING
An interesting Model to build and fly.

Kit No. 2 Contains

Complete parts, materials, fittings, Plans and Instructions for Building the three Models shown above. All for $1.50.
(Postage 15c Extra)

IDEAL BOEING
A smart Biplane Model that flies beautifully.

IDEAL ARMY FALCON
Another popular Biplane Model you'll want to build.

Kit No. 1 Contains

Complete parts, materials, fittings, Plans and Instructions for Building the three Models shown in this corner. All for $1.50. (Postage 15c Extra).

IDEAL TRAVELAIR
A Dandy Model of the famous "Mystery" Plane.

The Modern Way to Buy Model Planes!